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Reed Lake Water Quality Near Spruce Point Mine 1983

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Manitoba
Environment and
Workplace Safety
and Health

REED LAKE WATER QUALITY

NEAR SPRUCE POINT MINE

1983

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SUMMARY

Hudson Bay Mining and Smelting Company, Ltd. completed development of the Spruce Point Mine in 1981. The mine site is located on a point projecting from the south shore of Reed Lake. Reed Lake is the largest waterbody in the Grass River Provincial Park and is highly valued for its exceptional water quality. Development of the mine aroused concern that Reed Lake water quality might be jeopardized.

The present study was conducted in August, 1983. Its purpose was to develop a baseline of data which could be used to readily and speedily detect anthropogenic changes in water quality. The delineation of baseline included data on water physicochemistry, metal concentrations in sediments and metal residues in fish. Comparisons were made to other appropriate lakes in order to determine whether or not the data base derived was indicative of natural background.

The water physicochemistry was typical for lakes of the area which straddle the Precambrian - Ordovician geological boundary. Waters were moderately alkaline but had little buffering capacity. Toxic metals were not detected in the water column. Metals were present in sediments at atypically low concentrations. This was attributed to the sandy nature of the sediments. Metal residues in fish were generally low, but still within the range of natural background for the area.

It was concluded that the water physicochemistry, sediment metal concentrations and metal residues in fish evidenced no anthropogenic impact. Therefore, it was concluded that the data obtained was representative of natural background and could be used as baseline reference for subsequent impact assessment.

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1.0 INTRODUCTION

Mineral exploration in the Reed Lake - Wekusko Lake area of north-western Manitoba has occurred sporadically for the past approximately 70 years and numerous deposits of both precious and base metals have been located (Davies et al, 1962). Discovery of a major copper-zinc deposit on the south shore of Reed Lake (54°34, 100°24) was announced jointly by Freeport Canadian Exploration Company and Beth Mining Company in January, 1974 (Anon, 1974). Rights to the site were eventually acquired by Hudson Bay Mining and Smelting Company and the deposit was developed as the Spruce Point Mine. Mining of ore commenced in January, 1982 (Hudson Bay Mining and Smelting Co., Ltd., 1983).

The location of the mineral strike aroused a number of issues when development of the deposit was first proposed. The issues were highly volatile and were debated both publicly and within several provincial government departments. The proposed development was to be located within the Grass River Provincial Park and caused a major concern about the general issue of industrial development within provincial parks. Environmental degradation has been frequently linked to various mining developments and therefore, considerable concern was aroused about potential impacts upon Reed Lake; a waterbody considered by many to exemplify a semi-remote, pristine wilderness setting. Important spawning beds were located within one kilometer of the proposed development site and this aroused concern about potential pollution impacts upon the already stressed lake trout

population of Reed Lake. Reconciliation of these and other issues began in the fall of 1981 with the preparation of a draft master plan for the Grass River Provincial Park (Parks Branch, 1982). Fundamental to reconciliation of many of these issues was maintenance of water quality, for as recognized by the completed master plan, "Probably the most important feature of the Park is its excellent water quality...." (Parks Branch, 1984).

Protection of water quality lies within the mandated responsibility of the Department of Environment and Workplace Safety and Health. Assurance that water quality will be maintained in the face of a mineral development requires, in addition to regulatory controls*, a system of baseline measurements against which even minimal changes in water quality can be readily and speedily detected. This system of baseline measurements constitutes the purpose of the present report. Specific objectives established included delineation of background surface water physicochemistry and metal concentrations in both sediments and fish. Metal concentrations in fish and sediments also formed the basis for comparison to other northern Manitoba lakes situated near metal mine developments.

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* Recommended controls have been described by Moche (1983).

2.0 THE SETTING

The study area is located near the south shore of Reed Lake (54°40, 100°30), within the Grass River Provincial Park (Figure 1). The area is accessed by PTH #391.

2.1 Description of Area

Bedrock of the study area consists of Ordovician dolomitic limestones (Davies et al, 1962). These are overlain by glacio-lacustrine mineral sub-soils upon which a thin mantle of organic soils have developed (Parks Branch, 1984). Topography within the study area proper is flat. Northern coniferous forest is the climax vegetation community natural to the area.

Reed Lake, with an estimated surface area of 205.7 square kilometers (Blunt, 1975), is the largest lake in the Grass River chain. A maximum depth of 112 feet (34.1 m) was reported by Schlick (1964). The lake, with its many islands, is very scenic and is favored by vacationers from the United States. Reed Lake supports a moderate quality sport fishery for northern pike, walleye and lake trout (Bruederlin and Wright, 1981). A 46 unit Provincial campground and two privately owned lodges (58 beds combined) are also located on the lake (Ibid).

2.2 Spruce Point Mine

Initial exploratory drilling had indicated ore reserves in excess of 1,000,000 tons (900,000 tonnes) averaging 2% copper and

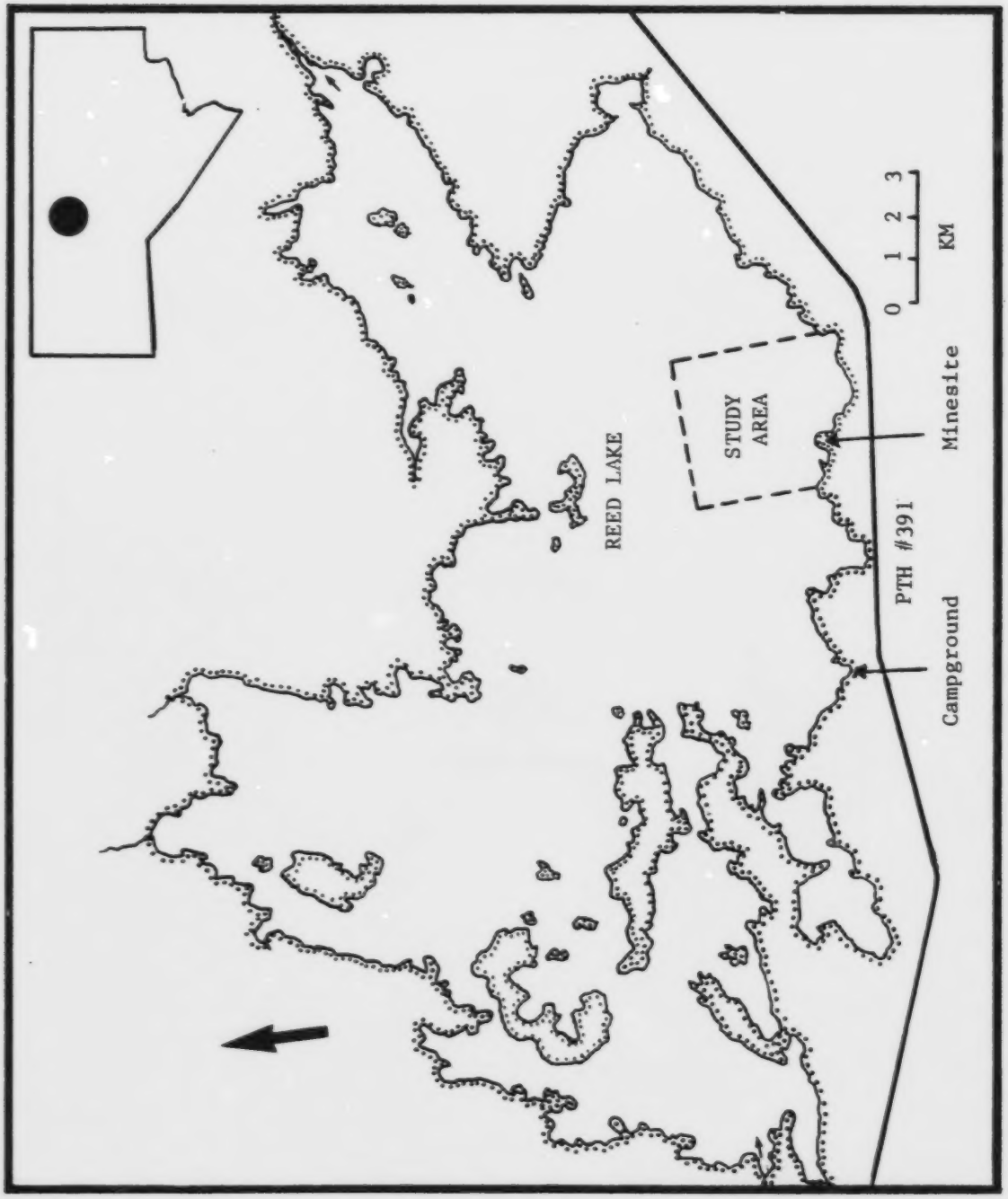

Figure 1: Spruce Point Mine study area.

4% zinc, as well as small amounts of silver and gold (Anon, 1974). Site preparation and mine development were completed in December, 1981, with first ore produced in January, 1982 (Hudson Bay Mining and Smelting Co., Ltd., 1983). Mining is currently conducted on a three shift per day, five day week (Ibid). The ore, 650 tonnes per operating day, is truck-hauled 140 kilometers to Flin Flon for processing (Ibid).

Hudson Bay Mining & Smelting Co., Ltd., (HBM&S) applied on April 3, 1979 to the Environmental Management Division under Section 14(1) of the Clean Environment Act for the discharge of contaminants from a proposed mine to be known as Spruce Point Mine. Subsequent to a public hearing held on January 8, 1980 in Flin Flon, the Clean Environment Commission (CEC) issued Order No. 870 on February 6, 1980. Order No. 870, issued against the development phase of the mine, required in part (Clause 3) that drainage, flow or seepage of effluent not be permitted north of Provincial Trunk Highway #391; i.e. towards Reed Lake. Inability to comply with Clause 3 and achievement of the production phase, led HBM&S to formally request issuance of a new Order for the production phase of the mine (Moche, 1983). This request was dated April 19, 1982. A Hearing to consider the request was held in Flin Flon on November 8, 1983. The CEC issued Order No. 1014 (Appendix I) against HBM&S on March 23, 1984. Currently, Order No. 1014 is under appeal to the

Minister, Environment and Workplace Safety and Health (C. Moche,* pers. comm.).

Two potential sources of contamination to Reed Lake were anticipated. Wastewater discharges, which could amount to approximately 400,000 m^3 per year (Moche, 1983), were the primary concern. Dust from haulage trucks and from the mine site, was a lesser concern.

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* C. H. Moche, P. Eng., Environmental Engineer, Water Pollution Control, Environmental Control Services. Manitoba Department of Environment and Workplace Safety and Health.

3.0 METHODS

3.1 Rationale

The sampling program was confined to various physicochemical constituents of water, sediments and fish. Only water, sediment and fish matrices were considered because of the relative simplicity of sampling, inexpensive cost of analysis and straight forward nature of interpretation as compared to the periodicity and ambiguity of plankton data and the highly specialized requirements for analysis and interpretation of benthic samples. Despite commencement of mining operations in January, 1982, it was assumed that samples collected in August, 1983 were still representative of predevelopment background. This assumption was tested, albeit crudely, by comparing random data to radial data and by comparison to select data from lakes near other mining operations.

The intent of the sampling program was to determine background water quality values. Accordingly, a random sampling strategy (Cassie, 1971) was applied to collection of water and sediment samples in order that normal statistical procedures could be adopted. Random procedures could not be applied to fish collection because samples were desired from the vicinity of the mine site and fish are highly mobile. Furthermore, catch success rates were poor. A second strategy, radial sampling, whereby sampling radii are extended from potential point sources, was also applied. Since radial sampling would likely be adopted in future surveys conducted to assess

impacts, it was necessary to determine both the present radii values and their relationship to normal background (i.e to the data from random stations).

3.2 Field Procedures

A block extending approximately 1.75 kilometers into Reed Lake and approximately 0.75 kilometers on either side of Spruce Point Mine was established for random sampling purposes (Figure 1). Sampling stations (Figure 2) were determined by superimposing a numbered grid upon a figure of the block and utilizing random number tables to select grid reference points. A total of 15 grid reference points were thus selected as random sampling stations.

A series of radii were extended by compass bearing from each of two potential point sources of contamination to Reed Lake (i.e. series A and B) and from the mouth of an unnamed influent stream (series C, Figure 3). Series "A" extended from the point of land upon which Spruce Point Mine is located. Series "B" extended from the mouth of an unnamed influent stream which drains a portion of the boggy area to which mine wastewaters are discharged. Series "C" was considered the control as significant anthropogenic sources of contamination were not known to occur within the stream's watershed. Sampling points along each of the radii (Table 1) were located primarily by triangulation.

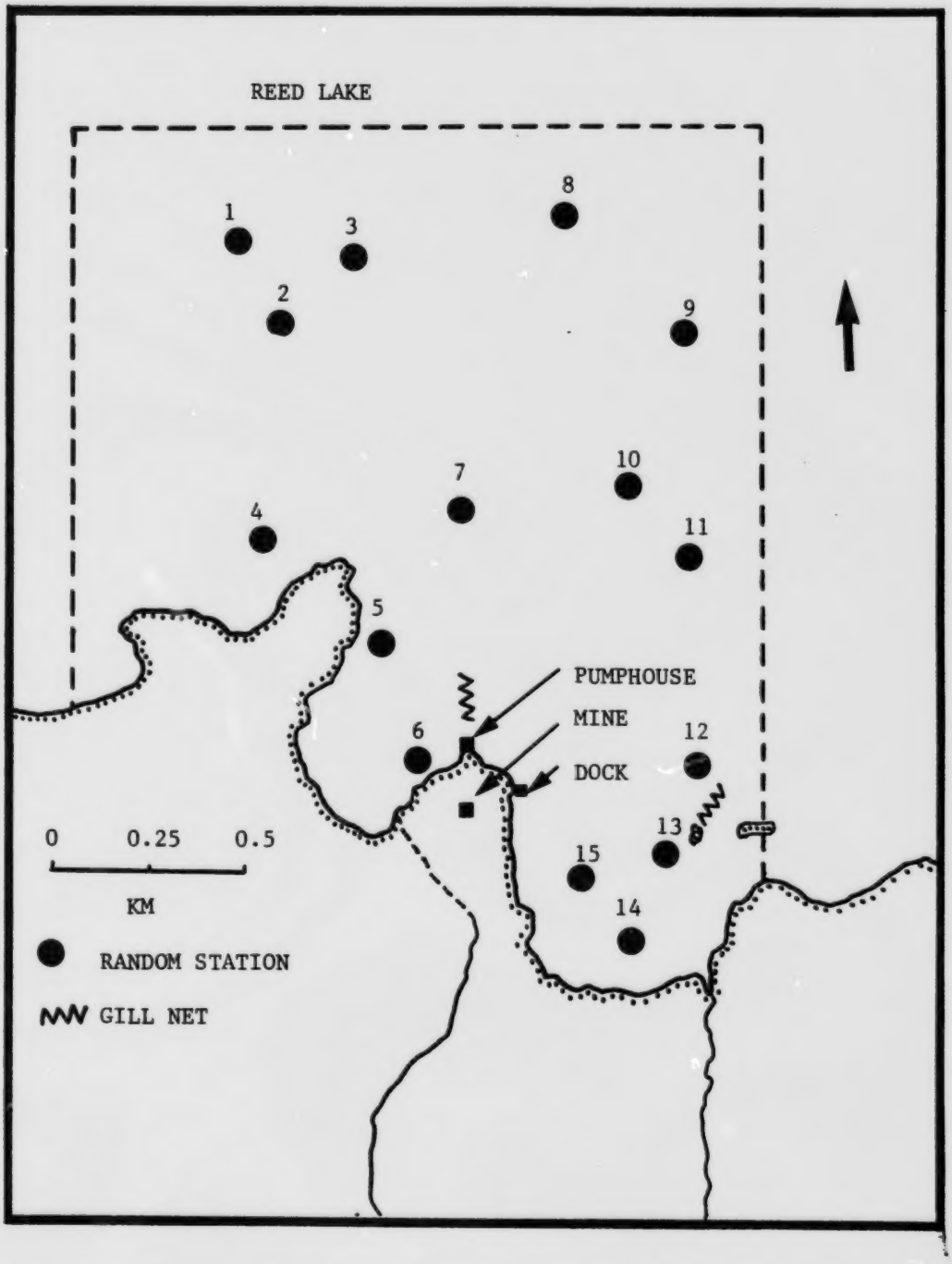

Figure 2: Spruce Point Mine random sampling stations and fish netting sites.

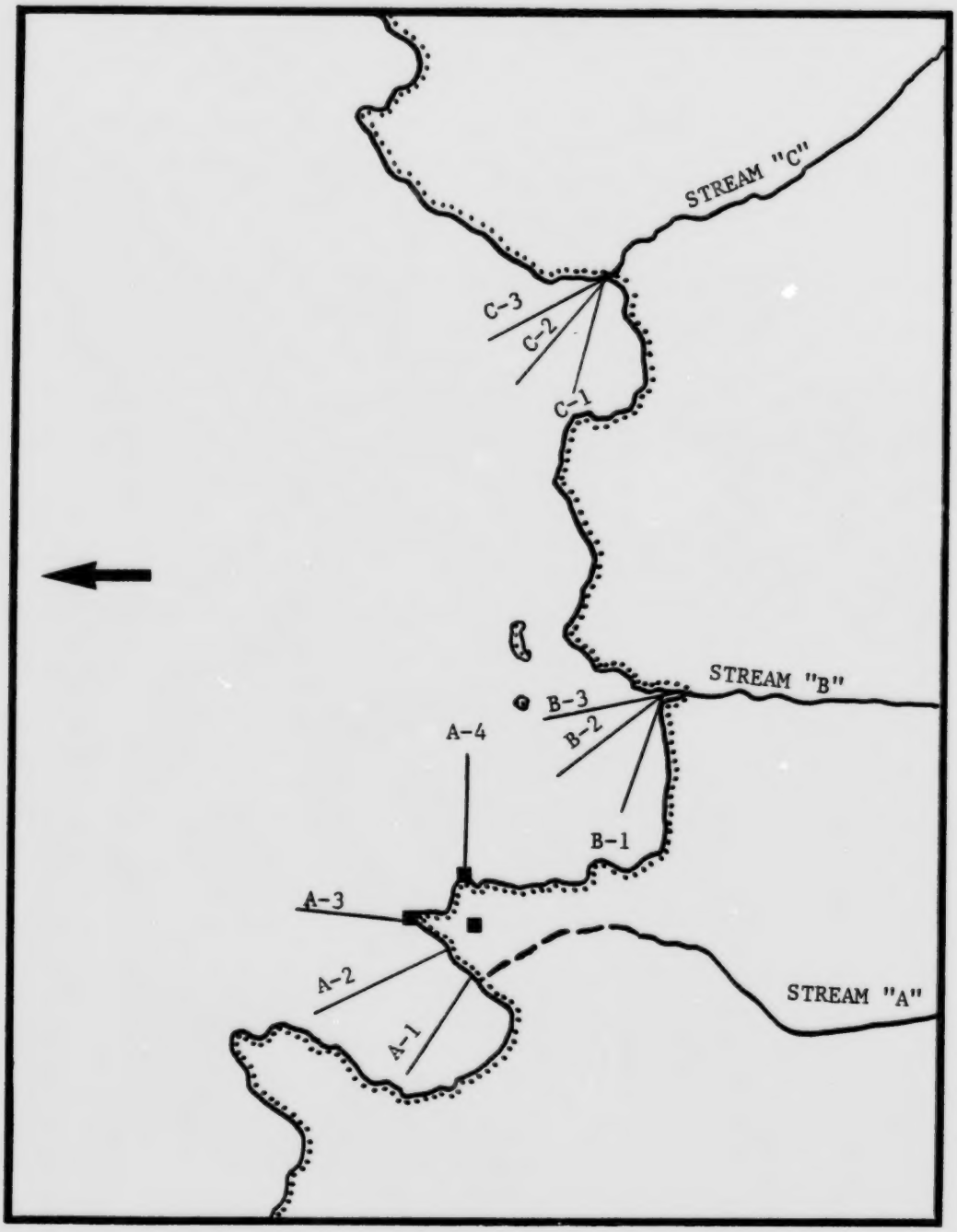

Figure 3: Spruce Point Mine sampling radii.

TABLE 1: LOCATION OF RADIAL SAMPLING POINTS

RADII	SOURCE*	ANGLE OF RADII (°)	POINT DISTANCE (M) FROM SOURCE -1	-2	-3	-4	-5
A-1	Land	290°	50	120	200	290	370
A-2	Land	320°	110	220	330	440	560
A-3	Pumphouse	0°	100	200	310	420	530
A-4	Dock	90°	100	200	300	400	500
B-1	Stream "B"	290°	100	175	250	325	400
B-2	Stream "B"	320°	120	240	360	480	600
B-3	Stream "B"	350°	80	160	240	320	430
C-1	Stream "C"	285°	100	200	300	400	500
C-2	Stream "C"	310°	100	200	300	400	500
C-3	Stream "C"	330°	100	200	300	400	500

* Per Figure 3

Water samples were collected on August 10, 1983 with a 4.4 liter acrylic Kemmerer style sampling bottle (trace metal grade). Sampling depths for all stations were determined by considering random numbers as a percentage of the total depth at each respective site. Containers were triple rinsed with sample water prior to filling. Samples were preserved according to standard procedures (Sorba et al, 1980), placed in coolers, iced and shipped by scheduled bus service so as to arrive at the analytical facility* within twenty-four hours of collection.

Single sediment samples from each station were collected using a 22.9 centimeter square Ekman dredge. Upon hoisting the Ekman grab to the lake surface, the top of the dredge was carefully opened so as to not disturb the delicate water-sediment interface. A five centimeter diameter clear acrylic tube was then inserted through the dredge contents. Excess water and sediments more than five centimetres below the interface were carefully drained from the pipe. The remainder of the sample was placed in a labelled whirlpac plastic bag. Samples were temporarily stored in the freezer of a local fishing lodge and maintained in a frozen state until delivery to the analytical facility.

Fish were collected by overnight deployment of two gangs of 45 m x 4.8 m x 95.3 mm and 45 m x 3.6 m x 108 mm mesh gill nets at suitable locations (Figure 2). The total catch was identified to

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* W. M. Ward Technical Services Laboratory, 745 Logan Avenue, Winnipeg, Manitoba.

species and tallied. A maximum of twenty representative individuals per species were selected for sampling. Each individual was assigned a unique identifying number, weighed to the nearest 10 grams, measured to the nearest 0.1 centimeter and sexed. Evidences of age*, consisting of either otoliths, cleithra or pelvic fin rays (species dependent), were removed at this time. Specimens were than filleted and samples of lateral muscle tissue inserted in labelled whirlpac plastic bags. Muscle tissue samples were temporarily stored in the freezer of a local fishing lodge and maintained in a frozen state until delivery to the analytical facility.

3.3 Analytical Procedures

Water, sediment and fish samples were analyzed by staff of the W. M. Ward Technical Services Laboratory according to procedures described by Sorba et al (1980). Fish evidences of age were submitted to the Biological Services Branch, Manitoba Department of Natural Resources for age determination according to methods adapted from Lagler (1952).

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* Evidence of age collected were otoliths from walleye and cisco, cleithra from northern pike and pelvic fin rays from common suckers.

4.0 RESULTS AND DISCUSSION

Data from water, sediment and fish samples are itemized in Appendices II, III and IV; respectively.

4.1 Water

The water physicochemistry will be discussed in terms of normal background for the area; i.e. as it pertains to the random block. Comparisons will then be made to each of the radii series in order to assess similarity; hence, suitability of radial data as background reference. Finally, because the "B" series of radii have the potential to affect Reed Lake by virtue of draining a portion of the mine wastewater disposal area, and because the "C" series of radii were to serve as an experimental control, series "B" and "C" will be discussed as they relate to each other.

Data summaries for each of the sampling blocks are presented in Table 2. Table 3 ranks the sampling blocks in order of highest to lowest physicochemical values and then illustrates statistically significant differences. Loadings of contaminants to Reed Lake directly from the mine site and from streams "B" and "C" are also illustrated in tabular form (Table 4) as significant ($\alpha = 0.05$) regressions of various physicochemical values on distance from the source. These latter were developed from an optimum curve fitting procedure (Hewlitt-Packard statistical package).

TABLE 2: SUMMARIZATION OF SPRUCE POINT MINE AREA (REED LAKE) WATER PHYSICOCHEMISTRY, AUGUST 10, 1983

SAMPLING BLOCK		RANDOM BLOCK (N = 15)				SERIES "A" (N = 20)			
PARAMETER	STATISTIC*	$\bar{x}$	δ	Hi	Lo	$\bar{x}$	σ	Hi	Lo
Conductivity	µS/cm	147.7	0.46	148.	147.	147.6	0.50	148.	147.
Total Residue	mg/L	121.	7.4	130.	110.	98.5	5.23	110.	86.
Filterable Residue	mg/L	121.	7.4	130.	110.	98.5	5.23	110.	86.
Nonfilterable Residue	mg/L	<5.	0	<5.	<5.	<5.	0	<5.	<5.
pH	units	8.18	-	8.30	8.05	8.23	-	8.30	8.05
Alkalinity	mg$CaCO_3$/L	72.	1.1	74.	70.	72.	1.3	74.	68.
Alkalinity	mgHCO_3/L	88.	1.3	90.	85.	88.	1.6	90.	83.
Alkalinity	mg/CO_3/L	0	0	0	0	0	0	0	0
Alkalinity	mgOH/L	0	0	0	0	0	0	0	0
Arsenic	mg/L	<0.001	0	0.001	<0.001	<0.001	0	0.001	<0.001
Cadmium	mg/L	<0.001	0	<0.001	<0.001	<0.001	0	<0.001	<0.001
Copper	mg/L	<0.01	0	<0.01	<0.01	<0.01	0	<0.01	<0.01
Lead	mg/L	<0.005	0	<0.005	<0.005	<0.005	0	<0.005	<0.005
Nickel	mg/L	<0.005	0	<0.005	<0.005	<0.005	0	<0.005	<0.005
Zinc	mg/L	<0.01	0	0.01	<0.01	<0.01	0	<0.01	<0.01
Mercury	µg/L	<0.02	0	<0.02	<0.02	0.02	0.009	0.06	<0.02
Calcium	mg/L	16.	0.4	17.	16.	17.	0.03	17.	16.
Magnesium	mg/L	9.	0.2	9.	8.	9.	0	9.	9.
Hardness	mg$CaCO_3$/L	78.	1.7	80.	74.	79.	1.21	81.	77.
Manganese	mg/L	0.02	0	0.02	<0.02	0.02	0.005	0.04	<0.02
Iron	mg/L	0.04	0.009	0.06	0.03	0.04	0.012	0.08	0.03
Potassium	mg/L	<5.	0	<5.	<5.	<5.	0	<5.	<5.
Sodium	mg/L	2.	0.1	3.	2.	2.	0.3	3.	2.
Dissolved Oxygen	mg/L	9.5	0.26	9.8	8.9	8.9	0.45	9.9	8.2
Total Organic Carbon	mg/L	16.2	2.75	19.5	11.0	14.7	2.45	19.0	11.5
Total Inorganic Carbon	mg/L	14.7	0.32	15.0	14.0	14.5	0.38	15.0	14.0
True Color	units	8.	2.4	10.	5.	8.	2.5	10.	5.
Turbidity	NTu	1.09	0.287	2.0	0.9	1.04	0.21	1.50	0.65
Total Kjeldhal Nitrogen	mg/L	0.39	0.043	0.45	0.35	0.42	0.037	0.45	0.35
Ammonia	mgN/L	<0.02	0	0.02	<0.02	<0.02	0	<0.02	<0.02
Nitrates-Nitrites	mgN/L	<0.01	0	<0.01	<0.01	<0.01	0	<0.01	<0.01
Total Phosphorus	mg/L	0.018	0.0026	0.020	0.015	0.018	0.0024	0.020	0.015
Chloride	mg/L	<2.	0	<2.	<2.	<2.	0	<2.	<2.
Sulphate	mg/L	4.	0.2	4.	3.	4.	0.5	4.	3.

* WHERE: $\bar{x}$ = Mean; δ = Standard Deviation; Hi = Greatest Value; Lo = Smallest Value; N = Number of Observations.

TABLE 2 (Cont'd): SUMMARIZATION OF SPRUCE POINT MINE AREA (REED LAKE) WATER PHYSICOCHEMISTRY, August 10, 1983

SAMPLING BLOCK		SERIES "B" (N = 15) **				SERIES "C" (N = 15)**			
PARAMETER	STATISTIC*	$\bar{x}$	δ	Hi	Lo	$\bar{x}$	σ	Hi	Lo
Conductivity	µS/cm	145.4	36.4	165.	149.	152.5	10.1	181.	147.
Total Residue	mg/L	122.	8.6	140.	110.	108.3	14.3	140.	94.
Filterable Residue	mg/L	119.	8.0	130.	110.	106.9	11.8	130.	94.
Nonfilterable Residue	mg/L	<6.	1.2	8.	<5.	<5.	1.1	8.	<5.
pH	units	8.24	-	8.30	8.10	8.19	-	8.30	8.00
Alkalinity	mg$CaCO_3$/L	75.	3.2	82.	72.	74.	5.1	88.	70.
Alkalinity	mgHCO_3/L	92.	4.0	100.	88.	91.	6.2	107.	85.
Alkalinity	mg/CO_3/L	0	0	0	0	0	0	0	0
Alkalinity	mgOH/L	0	0	0	0	0	0	0	0
Arsenic	mg/L	0.001	0.0003	0.002	<0.001	<0.001	0	0.001	<0.001
Cadmium	mg/L	<0.001	0	0.001	<0.001	<0.001	0	<0.001	<0.001
Copper	mg/L	<0.01	0	<0.01	<0.01	<0.01	0	<0.01	<0.01
Lead	mg/L	<0.005	0	<0.005	<0.005	<0.005	0	<0.005	<0.005
Nickel	mg/L	<0.005	0	<0.005	<0.005	<0.005	0	<0.005	<0.005
Zinc	mg/L	0.01	0.013	0.06	<0.01	<0.01	0	<0.01	<0.01
Mercury	µg/L	0.03	0.018	0.08	<0.02	0.02	0.003	0.03	<0.02
Calcium	mg/L	17.	0.8	18.	16.	17.	1.1	20.	16.
Magnesium	mg/L	9.	1.6	10.	3.	9.	0.8	11.	8.
Hardness	mg$CaCO_3$/L	79.	3.3	86.	76.	78.	5.4	94.	75.
Manganese	mg/L	0.02	0	0.02	<0.02	<0.02	0	<0.02	<0.02
Iron	mg/L	0.08	0.047	0.24	0.05	0.04	0.02	0.10	0.03
Potassium	mg/L	<5.	0	<5.	<5.	<5.	0	<5.	<5.
Sodium	mg/L	2.	0.4	3.	2.	2.	0.4	3.	2.
Dissolved Oxygen	mg/L	8.8	0.41	10.0	8.2	9.1	0.34	10.0	8.5
Total Organic Carbon	mg/L	13.1	1.78	17.0	11.0	12.2	1.90	18.0	10.5
Total Inorganic Carbon	mg/L	16.8	1.21	19.5	15.5	16.6	1.91	21.0	14.0
True Color	units	10.	2.7	15.	5.	9.	3.2	15.	5.
Turbidity	NTu	1.36	0.235	1.50	0.95	1.10	0.21	1.5	0.95
Total Kjeldhal Nitrogen	mg/L	0.62	0.041	0.70	0.60	0.68	0.05	0.75	0.60
Ammonia	mgN/L	<0.02	0	<0.02	<0.02	<0.02	0	<0.02	<0.02
Nitrates-Nitrites	mgN/L	<0.01	0	<0.01	<0.01	0.01	0.005	0.03	<0.01
Total Phosphorus	mg/L	0.019	0.0018	0.020	0.015	0.018	0.0025	0.020	0.015
Chloride	mg/L	<2.	0	<2.	<2.	<2.	0	<2.	<2.
Sulphate	mg/L	3.	0.5	4.	3.	3.	0.5	4.	3.

* WHERE: $\bar{x}$ = Mean; δ = Standard Deviation; Hi = Greatest Value; Lo = Smallest Value; N = Number of Observations.

** Stream mouth values (i.e. B-1 and C-1) have been excluded from calculations.

TABLE 3: RANK AND SIMILARITY OF SPRUCE POINT MINE AREA (REED LAKE) SAMPLING BLOCKS WATER PHYSICOCHEMISTRY

PARAMETER	RANK AND SIMILARITY*	PARAMETER	RANK AND SIMILARITY
Conductivity	C R A B	Magnesium	IDENTICAL
Total Residue	B R C A	Hardness	A B C R
Filterable Residue	R B C A	Manganese	IDENTICAL
Non Filterable Residue	B [R A C]	Iron	B [R A C]
pH	--	Potassium	IDENTICAL
Alkalinity ($CaCO_3$)	B C R A	Sodium	IDENTICAL
Alkalinity (HCO_3)	B C R A	Dissolved Oxygen	R C A B
Alkalinity (CO_3)	IDENTICAL	Total Organic Carbon	R A B C
Alkalinity (OH)	IDENTICAL	Total Inorganic Carbon	B C R A
Arsenic	IDENTICAL	True Colour	B C R A
Cadmium	IDENTICAL	Turbidity	B C R A
Copper	IDENTICAL	Total Kjeldhal Nitrogen	C B R A
Lead	IDENTICAL	Ammonia	IDENTICAL
Nickel	IDENTICAL	Nitrates-Nitrites	IDENTICAL
Zinc	IDENTICAL	Total Phosphorus	B [C R A]
Mercury	B [C R A]	Chloride	IDENTICAL
Calcium	[A B C] R	Sulphate	B C R A

* Per Duncan's Multiple Range Test ($\alpha = 0.05$) where sampling blocks are ranked from highest to lowest value, statistically indistinguishable blocks are underscored and identical blocks are boxed. Block symbols are as follows:
R - Random block;
A - "A" series of radii;
B - "B" series of radii;
C - "C" series of radii.

TABLE 4: SIGNIFICANT (t_{α} = 0.05) REGRESSIONS OF SPRUCE POINT MINE AREA (REED LAKE) WATER PHYSICOCHEMICAL PARAMETERS ON DISTANCE FROM SHORE (SERIES "A" RADII) AND ON DISTANCE FROM MOUTHS OF STREAMS (SERIES "B" AND "C" RADII).

RADII	PARAMETER	CURVE*	r^2**	a	b
"A"	SIGNIFICANT REGRESSIONS NOT ENCOUNTERED				
"B"	Conductivity	Linear	0.60	163.45	-0.03
		Exponential	0.60	163.42	-0.0002
		Logarithmic	0.57	167.21	-2.36
		Power	0.56	167.17	-0.01
	Total Residue	Linear	0.29	131.38	-0.03
		Exponential	0.28	131.06	-0.0002
		Logarithmic	0.30	135.92	-2.56
		Power	0.28	135.64	-0.02
	Non filterable Residue	Linear	0.42	7.32	-0.01
		Exponential	0.41	7.21	-0.0008
		Logarithmic	0.31	7.70	-0.35
		Power	0.30	7.64	-0.05
	Filterable Residue	Logarithmic	0.36	133.15	-2.62
		Power	0.33	132.70	-0.02
	pH	Linear	0.38	8.12	0.0004
		Exponential	0.38	8.12	0.00005
		Logarithmic	0.56	8.03	0.04
		Power	0.57	8.03	0.005
	Alkalinity ($CaCO_3$)	Linear	0.58	80.61	-0.02
		Exponential	0.58	80.59	-0.0002
		Logarithmic	0.52	82.56	-1.33
		Power	0.51	82.54	-0.02
	Alkalinity(HCO_3)	Linear	0.58	98.56	-0.02
		Exponential	0.59	98.53	-0.0002
		Logarithmic	0.54	101.14	-1.71
		Power	0.52	101.11	-0.02
	Calcium	Linear	0.40	19.42	-0.01
		Exponential	0.43	19.27	-0.0004
		Logarithmic	0.92	21.91	-0.89
		Power	0.89	21.71	-0.04
	Magnesium	Logarithmic	0.33	11.58	-0.53
	Hardness	Linear	0.41	90.40	-0.03
		Exponential	0.44	89.71	-0.0004
		Logarithmic	0.93	101.66	-4.03
		Power	0.91	100.80	-0.04
	Iron	Linear	0.44	0.17	-0.0003
		Exponential	0.59	0.15	-0.002
		Logarithmic	0.70	0.24	-0.03
		Power	0.63	0.22	-0.20

TABLE 4: CONT'D

RADII	PARAMETER	CURVE*	r^{2}**	a	b
"B" Cont'd	Total Inorganic Carbon	Linear	0.45	18.69	-0.01
		Exponential	0.46	18.67	-0.0004
		Logarithmic	0.50	19.64	-0.52
		Power	0.48	19.60	-0.03
	Sulphate	Logarithmic	0.37	4.50	-0.19
		Power	0.30	4.43	-0.05
"C"	Conductivity	Linear	0.31	220.68	-0.19
		Exponential	0.36	205.15	-0.0009
		Logarithmic	0.97	301.29	-26.65
		Power	0.97	282.31	-0.11
	Total Residue	Linear	0.33	163.66	-0.16
		Exponential	0.36	152.33	-0.001
		Logarithmic	0.90	219.69	-19.86
		Power	0.82	205.76	-0.12
	Filterable Residue	Linear	0.33	159.90	-0.15
		Exponential	0.38	148.43	-0.001
		Logarithmic	0.94	218.54	-20.0
		Power	0.88	204.19	-0.12
	pH	Logarithmic	0.74	7.68	0.09
		Power	0.76	7.67	0.01
	Alkalinity ($CaCO_3$)	Linear	0.30	112.77	-0.12
		Exponential	0.35	102.95	-0.001
		Logarithmic	0.97	159.62	-15.43
		Power	0.97	147.24	-0.12
	Alkalinity (HCO_3)	Linear	0.31	138.17	-0.13
		Exponential	0.36	126.25	-0.001
		Logarithmic	0.97	194.77	-18.60
		Power	0.97	179.81	-0.12
	Calcium	Linear	0.29	24.78	-0.02
		Exponential	0.32	22.57	-0.0009
		Logarithmic	0.95	35.08	-3.32
		Power	0.95	32.33	-0.12
	Magnesium	Linear	0.25	13.54	-0.01
		Exponential	0.25	12.07	-0.0009
		Logarithmic	0.93	19.71	-1.93
		Power	0.89	17.93	-0.13
	Hardness	Linear	0.29	118.29	-0.11
		Exponential	0.33	107.53	-0.001
		Logarithmic	0.96	167.91	-16.09
		Power	0.96	154.48	-0.12
	Iron	Linear	0.27	0.20	-0.0005
		Exponential	0.34	0.10	-0.003
		Logarithmic	0.95	0.42	-0.07
		Power	0.86	0.27	-0.35

TABLE 4: CONT'D

RADII	PARAMETER	CURVE*	r^2**	a	b
"C"					
Cont'd	Sodium	Linear	0.45	2.93	-0.002
		Exponential	0.46	2.82	-0.0009
		Logarithmic	0.78	3.52	-0.25
		Power	0.72	3.42	-0.09
	Dissolved Oxygen	Logarithmic	0.87	5.19	0.70
		Power	0.90	4.50	0.13
	Total Organic Carbon	Logarithmic	0.63	18.61	-1.14
		Power	0.57	18.09	-0.07
	Total Inorganic Carbon	Linear	0.34	27.45	-0.03
		Exponential	0.42	24.78	-0.001
		Logarithmic	0.96	39.45	-4.09
		Power	0.93	36.01	-0.14
	Colour	Linear	0.28	21.71	-0.03
		Logarithmic	0.91	37.03	-4.96
		Power	0.64	30.07	-0.22
	Total Kjeldhal Nitrogen	Logarithmic	0.26	0.76	-0.01

* Where: Linear = $y = a + bx$

Exponential = $y = ae^{bx}$

Logarithmic = $y = a + b \cdot \ln x$

Power = $y = ax^{b}$

** Where: Series "A" (N = 20), $t0.95 = r^2$ at 0.24; Series "B" + "C" (N = 16), $t2.95 = r^2$ at 0.25

Specific conductance, or conductivity, is a measure of the ability of water to conduct an electrical current. Because this ability is proportional to the presence of dissolved materials, conductivity provides a general indication of water purity. Mean conductivity for the random block (Figure 2) was 147.7 µS/cm (Table 2). This represents virtually no change from the mean of 149 µS/cm obtained by Blunt (1975) in 1974, and is within the range of values obtained in Wekusko Lake (100 to 184 µS/cm; Brown et al, 1980). (Wekusko Lake is a nearby waterbody which, like Reed Lake, also straddles the boundary between Precambrian and Ordovician bedrock formations.) A significant difference between sampling blocks was not detected at the 95% level of confidence (Table 3). This was despite indications that conductivity was significantly correlated to discharges from both streams "B" and "C" (Table 4). The inference was that although significant volumes of dissolved materials were contributed to Reed Lake by these streams, the assimilative capacity of the near shore areas sampled had thus far prevented a detectable elevation of conductivity within the respective sampling blocks. There was no indication that conductivity had been affected by particulates or other discharges emanating directly from the minesite as the optimum curve fitting procedure did not yield a significant regression for the "A" series of radii (Table 4).

Total residue is the sum of total dissolved materials, including colloids (i.e. filterable residue) plus suspended materials (i.e. nonfilterable residue). Mean total residue for the random block was 121 mg/L (Table 2). This value was somewhat greater than the mean

value (105 mg/L) obtained by Blunt (1975) but was within the 86-152 mg/L range for Wekusko Lake (Brown et al, 1980). Total residue from the random block and the "B" series of radii were statistically indistinguishable from each other, but both were significantly greater than the values from the "C" and "A" series of radii (Table 3). An explanation for this dichotomy was not evident from other physicochemical parameters. Although significant correlations were obtained for regressions of total residue versus proximity to the mouths of streams "B" and "C", the dissimilarity between blocks "A" and "R" suggested that stream loadings were not implicated as the source of statistical difference (Table 4). Additionally, analytical imprecision ($\pm$ 7.7% coefficient of variation; Sorba et al, 1980) could not fully account for the differentiation. The implication was that either mixing between the blocks was imperfect or, alternately, the data was anomalous due to sampling design incompatibility (i.e. random stations versus distance dependent stations).

Data for filterable residue (i.e. dissolved materials and colloids) mirrored total residue results (Table 2) and were interpretable in the same manner.

Non filterable residue represents those fractions of a water sample which will not pass through a prepared GF/C glass fibre filter; hence the term is synonymous with suspended solids or particulates. Mean nonfilterable residue from the random block and from the "A" and "C" series of radii were less then the 5 mg/L detection limit (Table 2). Values for the "B" series of radii (mean = < 6mg/L) were

significantly greater than those from the other blocks sampled (Table 3). However, the statistical differentiation was considered an artifact due to the $\pm$ 5mg/L level of imprecision for the analytical method (Sorba et al, 1980). Rather the importance of nonfilterable residue values lay in the greater propensity for detectable levels (i.e. $\geq$ 5mg/L) in the "B" and "C" series of radii (frequencies of 62.5% and 18.8%, respectively; Appendices II(c) and (d) respectively) as compared to that of the random block and the "A" series of radii (0% for both blocks; Appendices II(a) and (b), respectively). This is because significant loadings of nonfilterable residue by both streams "A" and "B" were inferred by significant correlations for regressions on distance from the stream mouths (Table 4), and because particulates can be the most important vehicle by which toxic metals are transported to lakes (Allan, 1986). The inference was that a ready mechanism was in place for transport of toxic metals from the mine wastewater disposal area (i.e. the watershed of streams "A" and "B") to Reed Lake. This mechanism was natural and was also active in the control stream (i.e. stream "C"), albeit to a lesser degree.

The relative acidity of water is indicated by the pH scale, where 7.0 represents neutrality and values above and below neutrality are respectively indicative of alkaline and acidic conditions. Mean pH for the random block was 8.18 units (Table 2), considerably more alkaline* than the mean of 7.45 units obtained by Blunt (1975).

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* pH is a logarithmic scale (negative) which enumerates the hydrogen ion concentration; hence an increase of one pH unit corresponds to a 10 fold increase in the hydrogen ion concentration (i.e. acidity).

However, this was not considered indicative of actual change. Rather, it was considered probable that both sets of data were normal for respective conditions. Routine water quality monitoring of Reed Lake at a single site, six grab samples per year basis indicated that pH can range from 7.00 to 8.60 units within a single year (Water Standards and Studies, unpublished data). In any event, values obtained from Reed Lake during the present study were within the rather extreme range (7.10 - 9.00 pH units) encountered at Wekusko Lake during a single sampling period (Brown et al, 1980). Overlapping ranges (extremes 8.00 to 8.30 units; Table 2) suggested that mean pH values from the sampling blocks of the present study were not dissimilar. Notwithstanding this apparent similarity, significant ($t_{\alpha} = 0.05$) correlations were obtained for regressions developed on distance from the mouths of streams "B" and "C"** (Table 4). The inference was that the buffering capacity of near shore areas of Reed Lake had thus far prevented detectable acidification of sampling blocks "B" and "C".

Both calcium carbonate and bicarbonate alkalinities provide a measure of respective cation availability within water; hence, a measure of the water's ability to buffer or neutralize acidic inputs. Mean calcium carbonate and bicarbonate alkalinities for the random block were 72 mg/L and 88 mg/L, respectively (Table 2). Similar to

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* B. Blunt A/Chief, Environmental Assessment and Review Process, Manitoba Department of Environment and Workplace Safety and Health.

** Acidic discharges are normal for streams draining areas of bogs.

pH, alkalinities observed in the present study were somewhat greater than the 61 mg/L and 74.5 mg/L, respectively, mean values obtained by Blunt (1975). These may be attributable to long sample storage times during the previous study (Ibid). Again, mean alkalinities encountered during the present study were within the range (34 - 96 mg/L, and 41.5 - 117 mg/L; respectively) reported by Brown et al (1980) for Wekusko Lake. Mean alkalinities for the random sampling block were statistically indistinquishable from those of the "A" and "C" series of radii, but were significantly less than mean alkalinities from the "B" series of radii (Table 3). However, alkalinities from the "B" and "C" series of radii were also statistically indistinquishable. Because the range between mean alkalinities of the random block and the "B" series of radii was comparatively small (i.e. 72 mg/L and 88 mg/L as compared to 75 mg/L and 92 mg/L, respectively; Table 2) the inference was that differences were an artifact of sampling design (i.e. random versus dependent stations). This inference was supported by significant correlations for regressions developed on distance from the mouths of streams "B" and "C" (Table 4). The implication was that discharges from stream "B" were slightly, but detectably, increasing calcium carbonate and bicarbonate alkalinities within the near shore area of the "B" series of radii. Determination of whether this phenomenon is natural or anthropogenic requires future comparison of the "B" and "C" series of radii.

Several toxic metals were detected infrequently (Table 2), and then only at levels well below criteria established for drinking

water in Canada (Federal-Provincial Working Group on Drinking Water, 1978) and in Manitoba (Williamson, 1986). This group included arsenic, cadmium and zinc. Statistically significant differences between the sampling blocks were not detected (Table 3). Additionally, significant correlations were not derived from regressions developed by the optimum curve fitting procedure (Table 4). The inference was that detectable loading of arsenic, cadmium and zinc to Reed Lake, either directly from the area of the mine site or from influent streams "B" and "C", had not occurred.

Failure to detect copper, lead or nickel in any of the water samples (Table 2) also implied nonexistent or undetectable rates of loading from the mine site area and from influent streams "B" and "C".

Mercury is a toxic metal of particular concern because it is known to bioaccumulate in fish. Mercury was not detected at any of the random sampling stations, but was detected infrequently at each of the series of radial sampling blocks (Table 2). Mean mercury concentrations in the "B" series of radii were significantly greater than those from each of the other sampling blocks (Table 3). Natural contamination of the "B" sampling area may have been implicated because mercury was detected in some sediment samples from this area. Alternately, the trace detections encountered may have been indicative of sampler contamination,* a situation which had occurred previously under similar circumstances (Beck, 1984).

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* Fish data also failed to support the hypothesis of a mercury contaminated "B" sampling block.

Calcium is of significance in surface waters because it provides an indication of buffering capacity, i.e. the ability to neutralize acidic inputs. The mean calcium concentration of the random block was 16 mg/L (Table 2). This was indicative of relatively low buffering capacity and was considerably reduced from the mean value (36.75 mg/L) reported by Blunt (1975). However, present values did not appear unusual when compared to the 8.0 - 21.7 mg/L range observed during routine water quality monitoring (Water Standards and Studies, unpublished data). Thus there was uncertainty whether the apparent decline in Reed Lake calcium concentrations was real or illusory. Mean calcium concentrations among the series of radii were identical to each other and were significantly greater than that of the random block (Table 3). Although significant correlations (Table 4) suggested that streams "B" and "C" were loading calcium to Reed Lake, the suggestion could have been a statistical artifact. This was because the analytical level of imprecision (9.7%; Sorba et al, 1980) exceeded the 1 mg/L difference between the means of the series of radii and that of the random block.

Like calcium, magnesium is also of interest because it is indicative of buffering capacity. The mean magnesium concentration of the random block was 9 mg/L (Table 2). A significant difference between the means of the various sampling blocks was not detected (Table 3). However, a series of significant correlations implied that discharges from both streams "B" and "C" were loading magnesium to Reed Lake (Table 4). The inference was that magnesium assisted buffering capacity of Reed Lake was not detectably enhanced by the stream discharges.

Hardness is defined as water's capacity to precipitate soap. This action is achieved primarily by calcium, magnesium and iron ions. As a summation of precipitate capacity expressed as calcium carbonate equivalency, hardness provides a measure of the total "strength" of cation activity. Mean hardness of the random block was 78 mg/L (Table 2), a moderate value not appreciably removed from the 82 mg/L level reported by Blunt (1975). Reed Lake hardness was within the 56 - 146 mg/L range for Wekusko Lake reported by Brown et al (1980). Although a significant difference between the sampling blocks of the present study was not detected (Table 3), significant correlations on distance implied significant loadings from discharges of streams "B" and "C" (Table 4). This was consistent with results obtained for calcium, magnesium and iron.

Manganese is of significance in limnetic systems because of its relationship to iron. Changes in the iron: manganese ratio (Fe:Mn) can signal changes in pH. The mean Fe:Mn for the random block of the present study was 2.0:1 (Table 2). This was within the range (1.0:1 to 16.0:1) reported for Wekusko Lake (Brown et al, 1980), although somewhat on the low end of the scale (Hutchinson, 1957).* Significant differences between the means of each sampling block were not detected (Table 3), nor were significant correlations obtained for regressions on distance from the mouths of streams "B" and "C" (Table 4). The inference was that activities at the mine site and

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* Comparison to previous work on Reed Lake could not be made as Blunt (1975) did not report manganese concentrations.

drainage from the watersheds of streams "B" and "C" had not detectably affected manganese concentrations in the water column locally up to the time of study.

Acidified drainage from base metal mines which work pyritic ores are typified by excessive iron levels. Thus measurement of iron concentrations can provide a signal that environmental stress is occurring. Mean iron concentrations within the random block were 0.04 mg/L (Table 2). This represented no apparent change from the <0.05 mg/L level reported by Blunt (1975). Mean concentrations of the "A" and "C" sampling blocks were identical to that of the random block; all three were significantly lower than the mean iron concentration of block "B" (Table 3). The statistical distinction between blocks "B" and "C" and not between "A", "R" and "C" was surprising because significant correlations on distance (Table 4) implied significant iron loadings by discharges from both streams "B" and "C". Because colloids, particulates and organic macromolecules are the significant vehicles for transport of iron in streams (Allan, 1986), it was inferred that differences in iron speciation were the reason for elevated iron concentrations within the "B" sampling block.

Potassium is a nutrient essential for the growth of plants. Levels were below the 5.0 mg/L detection limit at all stations sampled (Table 2). This is typical of Manitoba waterbodies (Water Standards and Studies, unpublished data).

Sodium is also a minor nutrient which has some significance as an indicator of municipal wastewater discharges. Mean concentrations were very low (2.0 mg/L) and uniform throughout the study area (Table 2).

Dissolved oxygen concentrations, the level of saturation in particular, is critical for the propogation and maintenance of all aerobic aquatic organisms. However, damage to the thermometers early in the survey prevented measurement of temperature. This precluded calculation and assessment of saturation levels.

Total organic carbon (TOC) provides a quantitative measurement of the organic material present in water. As such, it can provide an indication of organic loading. Mean TOC for the random block ("R") was 16.2 mg/L (Table 2). This was within the 12.5 - 33.5 mg/L range reported for Wekusko Lake (Brown et al, 1980). TOC values for blocks "A" and "R" were statistically indistinquishable from each other, but were significantly greater than those of blocks "B" and "C" (Table 3). Significant correlations obtained for regressions developed on distance for the "C" series of radii (Table 4) were considered spurious and the statistical distinction between blocks was attributed instead to depth dependent differing rates of productivity.* Anthropogenic sources were not implicated as the cause of statistical distinction.

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* Note that blocks "B" and "C", by design, bore a greater proportion of wave-washed zone than did blocks "A" and "R". Mean total depths for each series of sampling stations were: R = 3.63 m; A = 2.89 m; B = 2.22 m; C = 2.06 m.

Total inorganic carbon (TOC) provides a measure of carbon associated with inorganic (eg. mineral) sources. TIC results were generally the inverse of TOC results (Tables 2 & 3). Again, anthropogenic influences were not implicated by the data.

True colour in natural waters is imparted by organic materials such as tannic and humic acids. Mean colour in the random block was quantified at 8 units (Table 2), a relatively low value. Statistical distinctions detected (Table 3) were attributable to drainage from boggy watersheds.

Reed Lake waters were very clear as mean turbidity within the random block was 1.09 NTu (Table 2). Statistical distinctions (Table 3) were considered spurious as the maximum difference (0.28 NTu) was exceeded by the level of imprecision ($\pm$ 0.5 NTu) of the analytical procedure (Sorba et al, 1980). Anthropogenic impacts were not detected.

Important nutrients such as the nitrogen species and total phosphorus are of significance because interpretation of data can help to distinguish between the type of anthropogenic source which might cause radical changes in productivity. Given values reported for Wekusko Lake (Brown et al, 1980), nutrient levels observed in the present study (Table 2) were considered normal background.

Chloride, which might be indicative of wastewater discharges, was not detected at any of the sampling stations (Table 2).

The sulphate anion occurs naturally, but excessive levels can be indicative of a series of stresses including industrial contamination and advanced eutrophy. The mean levels encountered

through the study area (3 to 4 mg/L Table 2) were considered normal background and evidenced no suggestion of anthropogenic impact. Statistical distinctions between the "B"-"C" and "R"-"A" sampling blocks were considered spurious given the 25% coefficient of variation for low level analysis (Sorba et al, 1980).

4.2 Metals in Sediments

Sediments will first be discussed in terms of normal background for the area; i.e. results from the random block will be compared to other local lakes. Suitability of the series of radii as background (i.e. predevelopment) reference will then be assessed by comparison to results from the random block. Finally, the radial results will be examined for background evidence of metals loading from either of stream "B" and "C" or the area of the mine site. Data summaries for each of the sampling blocks are presented in Table 5. Comparisons between sediment metal concentrations in Reed Lake and some other local lakes are presented in Table 6. Table 7 ranks the sampling blocks in order of highest to lowest concentrations and illustrates statistically significant differences. Regressions developed for various radial metal concentrations on distance from potential sources are presented in Table 8.

Mercury was detected only in sediments from the "B" series of radii (Table 5). Failure to detect mercury in sediments from the random block appeared atypical of lakes in nearby mineralized areas. Sediments from other lakes unaffected by anthropogenic mercury

TABLE 5: SUMMARIZATION OF SPRUCE POINT MINE AREA (REED LAKE) SEDIMENT METAL CONCENTRATIONS

SAMPLING BLOCK	METAL CONCENTRATIONS (µg/g DRY WEIGHT) Hg (Wet**)	Hg	As	Cd	Cu	Pb	Ni	Zn	Fe	Mn	STATISTIC
	<0.02	<0.03	2.82	<1.	14.	7.	14.	36.	14967.	522.	$\bar{x}$
"R"	0	0.0035	3.64	0	9.2	6.0	14.7	25.8	12657.5	1245.3	σ
(N = 15)	<0.02	<0.04	15.5	<1.	41.	28.	64.	120.	54310.	5003.	Hi
	<0.02	<0.03	0.61	<1.	<1.	<5.	<5.	6.	1450.	30.	Lo
	<0.02	<0.03	1.18	<1.	6.	<5.	8.	15.	5668.	83.	$\bar{x}$
"A"	0	0	0.50	0	4.	0	3.9	9.3	4867.4	74.	σ
	<0.02	<0.03	2.90	<1.	21.	5.	21.	37.	21730.	280.	Hi
(N = 20)	<0.02	<0.03	0.63	<1.	<2.	<5.	<5.	6.	1090	17.	Lo
	0.02	0.03	1.39	<1.	11.	8.	11.	27.	10479.	210.	$\bar{x}$
"B"	0.0035	0.004	0.96	0	10.3	4.5	9.6	24.2	10432.	264.4	σ
(N = 16)	0.03	0.04	3.20	<1.	36.	18.	36.	82.	35480.	1001.	Hi
	<0.02	<0.03	0.35	<1.	<1.	<5.	<5.	4.	1090.	13.	Lo
"C"	<0.02	<0.03	1.12	<1.	5.	<5.	7.	15.	4978.	119.	$\bar{x}$
(N = 16)	0	0	0.80	0	4.5	0	4.8	14.6	5783.5	168.1	σ
	<0.02	<0.04	3.45	<1.	18.	5.	21.	50.	19550.	600.	Hi
	<0.02	<0.03	0.49	<1.	<1.	<5.	<5.	4.	720.	7.	Lo

* where: $\bar{x}$ = mean;
σ = standard deviation;
Hi = greatest value;
Lo = smallest value.

** Due to potential volatilization loss, mercury is also reported as wet weight.

TABLE 6: COMPARISONS ($t\alpha$ = 0.05) OF METAL CONCENTRATIONS IN SEDIMENTS FROM REED, SNOW, HERBLET, WEKUSKO AND SHERLETT LAKES

METAL (DRY WEIGHT)	COMPARISONS ($t\alpha$ = 0.05) OF REED LAKE TO:*			
	SNOW LAKE[1]	HERBLET LAKE[1]	WEKUSKO LAKE[2]	SHERLETT LAKE[3]
Mercury (Wet)	-	-	-	SH
Mercury	SN	-	WE	SH
Arsenic	SN	HE	WE	-
Cadmium	SN	-	WE	SH
Copper	SN	HE	WE	SH
Lead	SN	HE	WE	SH
Nickel	SN	HE	-	SH
Zinc	SN	HE	WE	SH
Iron	-	HE	WE	SH
Manganese	-	-	-	-

* Where: RE = significantly greater levels in Reed Lake;
SN = significantly greater levels in Snow Lake, Block A;
HE = significantly greater levels in Herblet Lake, Block "D";
WE = significantly greater levels in Wekusko Lake, Herb Bay;
SH = significantly greater levels in Sherlett Lake;
"-" = no significant difference.

1 Values used for comparison extracted from Beck, 1984.

2 Values used for comparison extracted from Brown et al, 1980.

3 Values used for comparison extracted from Beck, 1983.

TABLE 7: RANK AND SIMILARITY OF SPRUCE POINT MINE AREA (REED LAKE) SEDIMENT METAL CONCENTRATIONS

METAL (DRY WEIGHT)	RANK AND SIMILARITY*
Mercury (Wet Weight)	B [R A C]
Mercury	B [R A C]
Arsenic	R B A C
Cadmium	[R A B C]
Copper	R B A C
Lead	B R [A C]
Nickel	R B A C
Zinc	R B [A C]
Iron	R B A C
Manganese	R B C A

* Per Duncan's Multiple Range Test ($\alpha = 0.05$), where sampling blocks are ranked from highest to lowest value, statistically indistinguishable blocks are underscored and identical blocks are boxed. Symbols for blocks are as follows:
  R - Random block;
  A - "A" series of radii;
  B - "B" series of radii;
  C - "C" series of radii.

TABLE 8: REGRESSIONS OF SPRUCE POINT MINE AREA (REED LAKE) SEDIMENT METAL CONCENTRATIONS ON DISTANCE FROM SHORE (SERIES "A" RADII) AND ON DISTANCE FROM MOUTHS OF STREAMS (SERIES "B" AND "C" RADII).

METAL*	RADII**	REGRESSION***	r^2	a	b	Ho: $\beta = 0$ ($t\alpha = 0.05$)
Mercury	B	Linear	0.12	0.03	<0.001	$\beta = 0$
Arsenic	A-1	Log.	0.24	1.33	-0.09	$\beta = 0$
	A-2	Power	0.55	0.12	0.37	$\beta = 0$
	A-3	Power	0.10	0.69	0.11	$\beta = 0$
	A-4	Linear	0.10	1.12	0.002	$\beta = 0$
	B	Exp.	0.22	0.58	0.002	$\beta = 0$
	C	Exp.	0.36	0.51	0.002	$\beta \neq 0$
Copper	A-1	Log.	0.05	5.67	-0.48	$\beta = 0$
	A-2	Power	0.82	0.08	0.71	$\beta \neq 0$
	A-3	Linear	0.13	6.03	0.004	$\beta = 0$
	A-4	Exp.	0.30	4.71	0.002	$\beta = 0$
	B	Power	0.24	1.52	0.29	$\beta = 0$
	C	Exp.	0.53	0.82	0.005	$\beta \neq 0$
Lead	B	Power	0.03	5.46	0.04	$\beta = 0$
Nickel	A-2	Power	0.77	1.47	0.25	$\beta = 0$
	A-3	Linear	0.51	4.32	0.01	$\beta = 0$
	A-4	Exp.	0.43	5.23	0.002	$\beta = 0$
	B	Log.	0.02	7.77	0.64	$\beta = 0$
	C	Linear	0.12	3.98	0.01	$\beta = 0$
Zinc	A-1	Linear	0.17	4.65	0.004	$\beta = 0$
	A-2	Linear	0.87	2.35	0.03	$\beta \neq 0$
	A-3	Linear	0.15	16.50	0.02	$\beta = 0$
	A-4	Linear	0.04	19.00	0.01	$\beta = 0$
	B	Exp.	0.23	7.69	0.003	$\beta = 0$
	C	Exp.	0.26	3.79	0.003	$\beta \neq 0$
Iron	A-1	Linear	0.05	1359.73	0.44	$\beta = 0$
	A-2	Linear	0.94	-354.6	11.98	$\beta \neq 0$
	A-3	Linear	0.48	3880.7	11.70	$\beta = 0$
	A-4	Linear	0.13	5613.00	14.85	$\beta = 0$
	B	Exp.	0.22	2194.97	0.004	$\beta = 0$
	C	Exp.	0.41	657.00	0.005	$\beta \neq 0$

TABLE 8: CONTINUED

METAL*	RADII**	REGRESSION***	r^2	a	b	Ho: $\beta = 0$ ($t\alpha = 0.05$)
Manganese	A-1	Exp.	0.38	44.03	-0.002	$\beta = 0$
	A-2	Linear	0.92	6.92	0.12	$\beta \neq 0$
	A-3	Exp.	0.10	144.66	-0.002	$\beta = 0$
	A-4	Linear	0.01	124.70	0.05	$\beta = 0$
	B	Exp.	0.28	24.36	0.005	$\beta \neq 0$
	C	Exp.	0.51	6.78	0.01	$\beta \neq 0$

* Regressions not developed for metals which lacked data variability.

** Regressions were developed for each of the "A" series radii because each emanates from a separate source, unlike the "B" and "C" series of radii.

*** Per optimum curve derived where: Linear: $y = a + bx$

Exp. : $y = ae^{bx}$

Log. : $y = a + b \ln x$

Power : $y = ax^b$

loadings such as certain areas of Snow Lake, Wekusko Lake and Sherlett Lake, possessed significantly greater concentrations of mercury (Table 6). This indicated that Reed Lake, at least the Spruce Point Mine locale, was rather unique with respect to possessing very low levels of background mercury. A significant difference between the sampling blocks involved in the present study was not detected (Table 7). This suggested that each of the sampling blocks were eminently suitable for use as background reference. Failure to develop significant regressions on distance for any of the radial series (Table 8) implied that neither anthropogenic nor natural background loading of mercury had occurred in the area and confirmed that all radii were suitable for use as background reference.

The mean arsenic concentration in sediments from the random block was 2.82 $\pm$ 3.64 µg/g (Table 5). This was significantly lower than encountered in unimpacted areas of such nearby lakes as Snow, Herblet and Wekusko, but was statistically indistinguishable from Sherlett Lake (Table 6). The absence of statistical distinction between sampling blocks of the present study (Table 7) suggested that all radial blocks were suitable for use as background reference. Furthermore, failure to develop significant negative regressions* on distance (Table 8) implied that neither anthropogenic nor natural

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* Note that a positive correlation (i.e. positive "b" value) indicates rising concentrations in relation to increasing distance, whereas a negative correlation (i.e. negative "B" value) indicates declining concentrations in relation to increasing distance.

background loading of arsenic had occurred from the area of the minesite or from either of streams "B" or "C". This also confirmed that all radii were suitable for use as background reference. However, the occurrence of a positive correlation for the "C" series of radii implied the presence of an active mechanism for the offshore transport of arsenic. The inference was that evidence of potential future arsenic loadings from the mine site area or from either of streams "B" or "C" might be partially masked.

Cadmium was not detected at any of the Reed Lake sampling stations (Table 5). Thus it was similar to Herblet Lake and possessed significantly lower background concentrations than Snow Lake, Wekusko Lake or Sherlett Lake (Table 6). Lack of statistical distinction between sampling blocks (Table 7) and the absence of variability among the data implied that each of the series of radii were suitable for use as background reference.

Copper was potentially one of the metals of particular concern due to the nature of the Spruce Point Mine ore body. The mean concentration in sediments of the random block was 14 $\pm$ 9.2 µg/g (Table 5). This was remarkably low considering the proximity of the cuprous ore body and was significantly lower than natural background in nearby Snow Lake, Herblet Lake and Wekusko Lake (Table 6). Even though background levels of the present study were low, significant differences were detected between the sampling blocks (Table 7). However, sampling block "B", potentially of greatest concern due to drainage from the wastewater discharge area, was indistinguishable from either of the random block or from the "A" series of radii

(Table 7). This implied that future assessments of impacts upon the "B" block could still be made by comparison to either of the random block or the "A" series of radii. Failure to develop any significant negative correlations on distance (Table 8) implied that anthropogenic and natural loading of copper had not occurred from either the mine site area or from streams "B" or "C". Rather, development of two significant positive correlations (radii "A-2" and series "C"; Table 8) implied activity by an offshore transport mechanism. Similar to arsenic, the inference was that evidence of potential future copper loading from the mine site area or from either of streams "B" or "C" might be partially masked.

The mean lead concentration in sediments of the random block was 7. $\pm$ 6.0 µg/g (Table 5). This was significantly lower than encountered in natural background areas of Snow Lake, Wekusko Lake, Herblet Lake or in Sherlett Lake (Table 6). An apparent significant difference between sampling blocks (Table 7) was considered a statistical artifact. This was because low level detections create no variation among data and because minor differences between means which are near the limit of detection might be eclipsed by the level of analytical error. [Sorba et al (1980) do not cite precision and accuracy data for analysis of copper in sediment, but $\pm$ 25% accuracy at the lower limit of detection would not be considered unreasonable.] In any event, the low background lead concentrations encountered during the present study were considered likely to rapidly evidence any potential future loadings of lead from either the mine site area or from streams "B" or "C'.

The mean nickel concentration in sediments of the random block was 14 ± 14.7 µg/g (Table 5). This was similar to background levels encountered in Wekusko Lake but was significantly lower than background in Snow Lake, Herblet Lake and Sherlett Lake (Table 6). The absence of statistical distinction between sampling blocks (Table 7) of the present study suggested that all radial blocks were suitable for use as background reference. Failure to develop significant regressions on distance (Table 8) implied that nickel loading had not occurred in the area and confirmed that all radii were suitable for use as background reference.

Similar to copper, zinc was also potentially of particular concern due to the nature and proximity of the Spruce Point Mine ore body. Mean zinc concentrations in sediments of the random block were 36 ± 25.8 µg/g (Table 5). This was significantly lower than background levels encountered in Snow Lake, Herblet Lake, Wekusko Lake or Sherlett Lake (Table 7). Sampling block "B" was statistically indistinguishable from the other blocks of the present study, whereas the random block possessed significantly greater levels than did the "A" and "C" series of radii. Similar to arsenic and copper, an offshore transport mechanism was implicated by development of two significant correlations on distance (radii A-2 and "C" series; Table 8), and likely was the source of significant differences detected between sampling blocks. Again, the inference was that evidence of potential future zinc loading from the mine site area or from either of streams "B" or "C" might be partially masked.

Unlike the metals discussed previously, iron in sediments was not of concern with regard to bioavailability of a toxic metal. Rather, changes in iron depositions might be indicative of influences from acidic drainages. Mean iron concentrations in sediments from the random block were 1.5 $\pm$ 1.27% (Table 5). This was similar to background in Snow Lake and was significantly lower than background in Herblet Lake, Wekusko Lake or Sherlett Lake. Similar to zinc, the mean iron concentrations from the "B" series of radii was statistically indistinguishable from the other sampling blocks, whereas the random block possessed significantly greater levels than did the "A" and "C" series of radii (Table 7). An offshore transport mechanism was again implicated by significant positive correlations at radii A-2 and series "C" (Table 8). This mechanism may have involved preferential deposition of iron laden particulates (Allan, 1986) in deepwater as opposed to wave resuspension and eventual removal of fine particles from shallow, inshore areas. Similar to arsenic, copper and zinc, the inference was that evidence of potential future iron loading from the mine site area from either of streams "B" or "C" might be partially masked.

Manganese, like iron, has some relevance to acidic discharges rather than toxicity to biota. Levels encountered during the present study varied so greatly (Table 5) that they were considered to offer little interpretive value for future assessments.

4.3 Metals in Fish

Fish are highly mobile organisms. Therefore, metal concentrations encountered were considered indicative for Reed Lake rather than for any specific sampling block of the study area. Mean metal concentrations encountered (Table 9) were discussed in terms of statistical similarities to fish from other lakes (Table 10).

A total of 88 specimens representing four fish species were collected. Common sucker was the most abundant species collected and accounted for 66% of the total catch.

Mean arsenic residues in muscle tissues of Reed Lake fish were low and ranged from 0.04 to 0.05µg/g (Table 9). These were not significantly different from residues encountered in fish from Snow Lake or Wekusko Lake (Table 10); nearby waterbodies from which the fish are considered to possess normal background arsenic body burdens (Beck, 1984; Brown et al, 1980). Fish from Herblet Lake demonstrate elevated arsenic residues due to drainage from arsenical tailings (op. cit.) and bore significantly greater residues than did Reed Lake fish (Table 10). Though low, residues encountered in Reed Lake fish were significantly greater (Table 10) than the ultra-low residues reported in fish from Sherlett Lake (Beck, 1983) and Gods Lake (Beck, 1982). Given these comparisons, arsenic residues encountered in Reed Lake fish during the present study were considered within the range of natural background for the locality.

Cadmium residues were not detected in any of the fish sampled from Reed Lake (Table 9). This was typical of the northern Manitoba

TABLE 9: SUMMARIZATION OF METAL CONCENTRATIONS IN MUSCLE TISSUE OF FISH FROM THE SPRUCE POINT MINE AREA OF REED LAKE

		GENERAL MERISTICS				MUSCLE TISSUE METAL CONCENTRATIONS (µg/g)						
STATISTIC*		LENGTH (cm)	WEIGHT (g)	SEX (M:F)	AGE (YRS)	ARSENIC	CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
						COMMON SUCKER						
N	$\bar{x}$	39.6	949.	0.25	8.	0.04	<0.1	0.2	0.7	0.05	<0.5	3.3
=	σ	2.21	172.3		2.1	0.012	0	0.15	0.35	0.020	0	0.62
20	Hi	43.8	1360.		13	0.06	<0.1	0.6	1.5	0.09	<0.5	4.5
	Lo	36.7	670.		6	0.01	<0.1	0.1	<0.5	0.02	<0.5	2.2
						WALLEYE						
N	$\bar{x}$	45.9	1202.	0.38	9.	0.05	<0.1	0.2	0.5	0.19	<0.5	4.3
=	σ	5.49	396.7		2.2	0.014	0	0.16	0.12	0.084	0	1.10
18	Hi	58.6	2220		13	0.07	<0.1	0.7	1.0	0.43	<0.5	8.1
	Lo	33.6	470		6	0.02	<0.1	0.1	<0.5	0.05	<0.5	3.2
						NORTHERN PIKE						
N	$\bar{x}$	62.6	2133	0.25	5	0.04	<0.1	0.2	0.6	0.16	<0.5	5.1
=	σ	16.96	1148.8		2.0	0.006	0	0.08	0.20	0.084	0	0.59
6	Hi	78.0	3580		6	0.05	<0.1	0.4	1.0	0.28	<0.5	6.1
	Lo	31.2	260		1	0.03	<0.1	0.2	<0.5	0.04	<0.5	4.6
						CISCO						
N	$\bar{x}$	37.3	740	0.5	8	0.04	<0.1	0.3	<0.5	0.08	<0.5	4.4
=	σ	4.10	181.6		2.0	0.008	0	0.11	0	0.010	0	1.1
6	Hi	40.5	1000		11	0.05	<0.1	0.4	0.5	0.09	<0.5	6.3
	Lo	29.7	440		5	0.03	<0.1	0.2	<0.5	0.06	<0.5	3.0

* Where: $\bar{x}$ = mean;
σ = standard deviation;
Hi = largest value;
Lo = smallest value.

TABLE 10: COMPARISONS ($t_{\alpha} = 0.05$) OF METAL CONCENTRATIONS IN MUSCLE TISSUE OF FISH FROM REED, SNOW, HERBLET, WEKUSKO, SHERLETT AND GODS LAKES.

LAKE VS LAKE	SPECIES	LAKE[1] WITH SIGNIFICANTLY GREATER METAL CONCENTRATION ($t_{\alpha} = 0.05$)						
		ARSENIC	CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC
Reed	Common Sucker	--	--	SN	RE	--	--	SN
vs	Walleye	--	--	SN	--	--	SN	--
Snow[2]	Northern Pike	--	--	SN	--	SN	SN	--
Reed	Common Sucker	HE	--	HE	RE	HE	--	HE
vs	Northern Pike	HE	--	--	--	HE	--	--
Herblet[2]	Cisco	HE	--	RE	--	HE	--	HE
Reed	Common Sucker	--	--	WE	--	WE	WE	WE
vs	Walleye	--	--	WE	--	--	WE	--
Wekusko[3]	Northern Pike	--	--	--	--	--	--	--
	Cisco	WE	--	--	WE	--	WE	WE
Reed	Common Sucker	RE	--	--	--	SH	--	--
vs	Walleye	RE	--	--	--	SH	--	--
Sherlett[4]	Northern Pike	RE	--	SH	--	--	--	RE
	Cisco	--	--	SH	--	SH	--	--
Reed	Common Sucker	RE	--	GO	RE	--	--	--
vs	Walleye	RE	--	--	--	--	--	GO
Gods[5]	Northern Pike	RE	--	--	--	GO	--	GO

[1] Where: RE = Reed Lake
SN = Snow Lake
HE = Herblet Lake
WE = Wekusko Lake
SH = Sherlett Lake
GO = Gods Lake

[2] Means for this lake were extracted from Beck, 1984.

[3] Means for this lake were extracted from Brown et al, 1980.

[4] Means for this lake were extracted from Beck, 1983.

[5] Means for this lake were extracted from Block "A" (the south basin of Gods Lake) in Beck, 1982.

lakes considered for comparative purposes (Table 10).

Mean copper residues were also low and ranged from 0.2 to 0.3 µg/g (Table 9). Consistently significant differences within species compared per lake were detected only for Snow Lake fish which had significantly greater residues (Table 10). This implied that copper residues detected in Reed Lake fish were not extraordinary, but rather were indicative of natural background.

Lead was detected infrequently and mean residues ranged from <0.5 to 0.7 µg/g (Table 9). Consistently significant differences within species were not detected for any of the lakes compared (Table 10). This implied that lead residues detected in the muscle tissue of Reed Lake fish were within the range of natural background.

Mean mercury residues were also low and ranged from 0.05 µg/g in common suckers to 0.19 µg/g in walleye (Table 9). Residues greater than the 0.50 µg/g Canada limit were not detected in any of the samples. Consistently significant differences within species compared per lake were detected only for Herblet Lake fish; these latter had significantly greater residues (Table 10). These comparisons implied that mercury residues encountered during the present study were indicative of natural, low-level background.

Like cadmium, nickel residues were not detected in any of the fish sampled from Reed Lake (Table 9). Again, this was typical of the northern Manitoba lakes used for comparison (Table 10).

Mean zinc residues were also low and ranged from 3.3 to 5.1 µg/g (Table 9). Consistently significant differences within species among the lakes compared were not detected (Table 10).

Generally, where differences were detected, Reed Lake fish were typified by significantly lower zinc residues (Table 10). Once again this implied that zinc residues encountered during the present study were indicative of natural background.

Consistent differences within species among the lakes compared were infrequent and the majority of comparisons did not indicate a significant difference (Table 10). This did not correspond closely to comparisons of metal concentrations in sediments (Table 6). Evidently, metal concentrations in sediments from the Spruce Point Mine area of Reed Lake do not provide a reliable relative estimate of potential metal bioavailability. This was attributed to the relative prominence of sand in Reed Lake sediments and more accurate comparisons would perhaps best be based upon values corrected for silica content (Allan, 1986).

5.0 CONCLUSIONS

It was concluded that:

In the vicinity of the Spruce Point Mine, Reed Lake water column physicochemistry, sediment metal concentrations and metal residues in fish demonstrate no evidence of anthropogenic impact. Therefore data documented within the present report is representative of natural background and may therefore be used as baseline reference for subsequent impact assessment.

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7.0 APPENDICES

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AN ORDER OF THE CLEAN ENVIRONMENT COMMISSION

UNDER THE CLEAN ENVIRONMENT ACT

RE: THE CLEAN ENVIRONMENT COMMISSION and HUDSON BAY MINING AND SMELTING CO., LIMITED, Applicant,

WHEREAS pursuant to the provisions of The Clean Environment Act, Hudson Bay Mining and Smelting Co., Limited filed a proposal with the department in connection with an operation for the development phase of a mine known as Spruce Point Mine located on unsurveyed land portions of M.C.'s Reed 18 and 28, (P.4414E, P.4423E) now part of E.A.L. 26, Lot 46, Group 371, Township 64, Range 20 WPM at or near the south shore of Reed Lake, Manitoba, with the discharge of contaminants to the environment;

AND WHEREAS the Commission held a hearing in Flin Flon on the 8th day of January, 1980, and issued Order No. 870 on the 6th day of February, 1980, prescribing limits, terms and conditions in connection with the development phase of the said mine;

AND WHEREAS the Applicant filed a second proposal with the department in connection with the said mine;

AND WHEREAS in the absence of limits, terms and conditions prescribed by a regulation under the said Act, the second proposal was referred to the Commission to prescribe limits, terms and conditions;

AND WHEREAS after giving notice of the second proposal and of its intention to consider rescinding the said order, the Commission received notice of representation from a person likely to be affected by an order of the Commission prescribing limits, terms and conditions;

AND WHEREAS the Commission held a hearing in Flin Flon on the 8th day of November, 1983;

AND WHEREAS the Commission considered the proposal on the 16th day of January, the 20th day of February, and the 21st day of March, 1984;

IT IS HEREBY ORDERED THAT

1. The Applicant shall not permit the discharge of effluent from the said operation directly to the waters of Reed Lake.

2. The Applicant shall not permit the discharge or deposit to the environment of:

   (a) raw or untreated sewage;

   (b) sewage sludge;

   (c) garbage or bulky metallic wastes

   except to an authorized waste disposal ground in accordance with regulations issued under the said Act.

3. The Applicant shall:

   (a) on or before the 1st day of February, 1985, submit a report to the Environmental Management Division demonstrating a plan for actions, and/or for the construction or installation of facilities that will positively ensure compliance with 3(b).

   (b) on and after the 1st day of February, 1986, not permit the effluent from the said operation to be discharged or to drain, flow or seep to the land or to any body of water located north of Provincial Trunk Highway No. 391;

4. The Applicant shall not permit the discharge of effluent from the sewage treatment plant serving the said operation where the content of the effluent, as measured at the outfall from the said plant, exceeds the following limits:

   (a) five-day biochemical oxygen demand not in excess of 30 milligrams per litre at any time;

   (b) suspended solids content not in excess of 30 milligrams per litre at any time.

5. The Applicant shall not permit the stockpiling or retention of:

   (a) ore or tailings;

   (b) waste rock in excess of 200,000 tons; or

   (c) subject to (b), piles of waste rock in excess of 15 feet in height;

   on the site of the said operation.

6. The Applicant shall not discharge effluent from the final discharge point where:

   (a) the concentrations of the following contaminants in the effluent are in excess of the corresponding maximum allowable concentrations shown for those categories listed under Columns I, II, and III of the following table:

	Contaminant	Column I Maximum Monthly Arithmetic Mean Concentration	Column II Maximum Concentration In a Composite Sample	Column III Maximum Concentration In a Grab Sample
(i)	Total Arsenic	0.5 mg/L	0.75 mg/L	1.0 mg/L
(ii)	Total Copper	0.3 mg/L	0.45 mg/L	0.6 mg/L
(iii)	Total Lead	0.2 mg/L	0.3 mg/L	0.4 mg/L
(iv)	Total Nickel	0.5 mg/L	0.75 mg/L	1.0 mg/L
(v)	Total Zinc	0.5 mg/L	0.75 mg/L	1.0 mg/L
(vi)	Total Suspended Matter	25.0 mg/L	37.5 mg/L	50.0 mg/L

   (b) where the pH of the effluent is below the minimum allowable values shown for those categories listed under Columns I, II and III of the following table:

Minimum Monthly Arithmetic Mean pH	Minimum pH In A Composite Sample	Minimum pH In A Grab Sample
6.0	5.5	5.0

7. Subject to 8, the Applicant shall sample and analyze the effluent at the final discharge point:

(a) for the following substances at no less a frequency than is specified in the table below where the applicability of Columns I, II, III and IV for each substance listed shall be determined on the basis of the arithmetic mean concentration of that substance in the samples of effluent collected and reported in those preceding six months during which effluent discharge occurred:

Substance	Column I At Least Weekly If Concentration Is Equal To Or Greater Than	Column II At Least Every Two Weeks If Concentration Is Equal To Or Greater Than	Column III At Least Monthly If Concentration Is Equal To Or Greater Than	Column IV At Least Every Six Months If Concentration Is Less Than
Total Arsenic	0.5 mg/L	0.2 mg/L	0.10 mg/L	0.10 mg/L
Total Copper	0.3 mg/L	0.1 mg/L	0.05 mg/L	0.05 mg/L
Total Lead	0.2 mg/L	0.1 mg/L	0.05 mg/L	0.05 mg/L
Total Nickel	0.5 mg/L	0.2 mg/L	0.10 mg/L	0.10 mg/L
Total Zinc	0.5 mg/L	0.2 mg/L	0.10 mg/L	0.10 mg/L
Total Suspended Matter	25.0 mg/L	20.0 mg/L	15.0 mg/L	15.0 mg/L

(b) for pH at no less a frequency than as is specified in the following criteria:

(i) once a week where the pH of the effluent was less than 5.0 at any time in those preceding six months during which effluent discharge occurred;

(ii) once every two weeks, where the pH of the effluent was between 5.0 and 5.5 at any time in those preceding six months during which effluent discharge occurred;

(iii) once a month if (i) and (ii) do not apply.

8. The Applicant shall sample and analyze the effluent from the said operation at the final discharge point in such a manner and for such additional parameters and characteristics and for such frequency and duration of time as is specified in writing by the Commission.

9. The Applicant shall determine the volume of effluent discharged monthly from the final discharge point by a suitable measurement technique or by estimation when the measuring equipment malfunctions.

10. The Applicant shall submit the analysis and measurement data determined in accordance with 7, 8, and 9 to reach the Enviromental Management Division, in a form acceptable to the said Division, not later than 30 days following the end of the month in which the samples and measurements were taken.

11. The Applicant shall, at the request of the Commission, from time to time, investigate specific areas of concern regarding any segment or component of the wastewater treatment or handling systems of the said operation and provide the Commission with such engineering studies, drawings, specifications, analyses of wastewater streams and such other information as is so requested.

12. The Applicant shall:

(a) within one year of the date of issuance of this order, submit to the Commission a preliminary rehabilitation plan for the site of the said operation with respect to the eventual closing and abandonment of the Spruce Point Mine, for review, possible amendment and approval of the Commission;

(b) upon termination of the said operation, take all necessary steps to carry out the approved rehabilitation plan within the interval of time specified by the Commission.

13. In this order:

(a) "final discharge point" means the end of the 15.24 centimetre diameter underground minewater pipe in the pumpout tank facility located on the surface immediately south of the sewage treatment plant (see Appendix 'A') serving the said operation unless otherwise designated in writing by the Commission;

13. (b) "monthly arithmetic mean" means for each substance, the average of all concentrations of the substance determined from the analysis of all composite and grab samples collected and reported during that month with the exception that, if the Applicant collects only one composite or grab sample during a single month, the single set of analytical results shall be contrued to be representative of the effluent quality for that month and hence shall be treated as the monthly arithmetic mean;

13. (c) "composite sample" means a quantity of effluent consisting of a minimum of three equal volumes of effluent collected at approximately equal time intervals over a sampling period of not less than 7 hours and not more than 24 hours, or consisting of effluent collected continuously at an equal rate over a sampling period of not less than 7 hours and not more than 24 hours.

14. This order replaces Order No. 870 which is hereby rescinded.

Order No. 1014

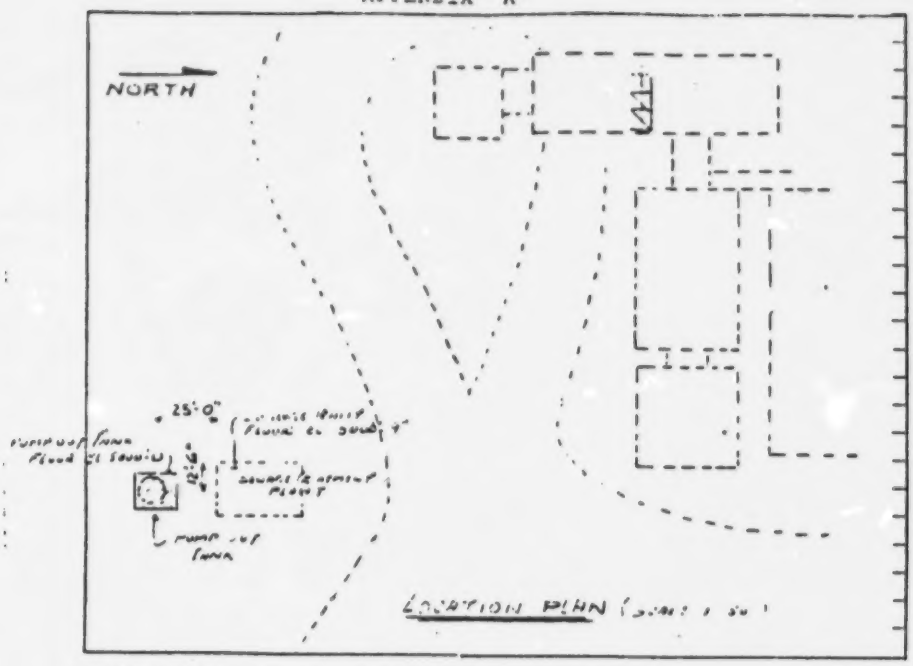
Dated at the City of Winnipeg

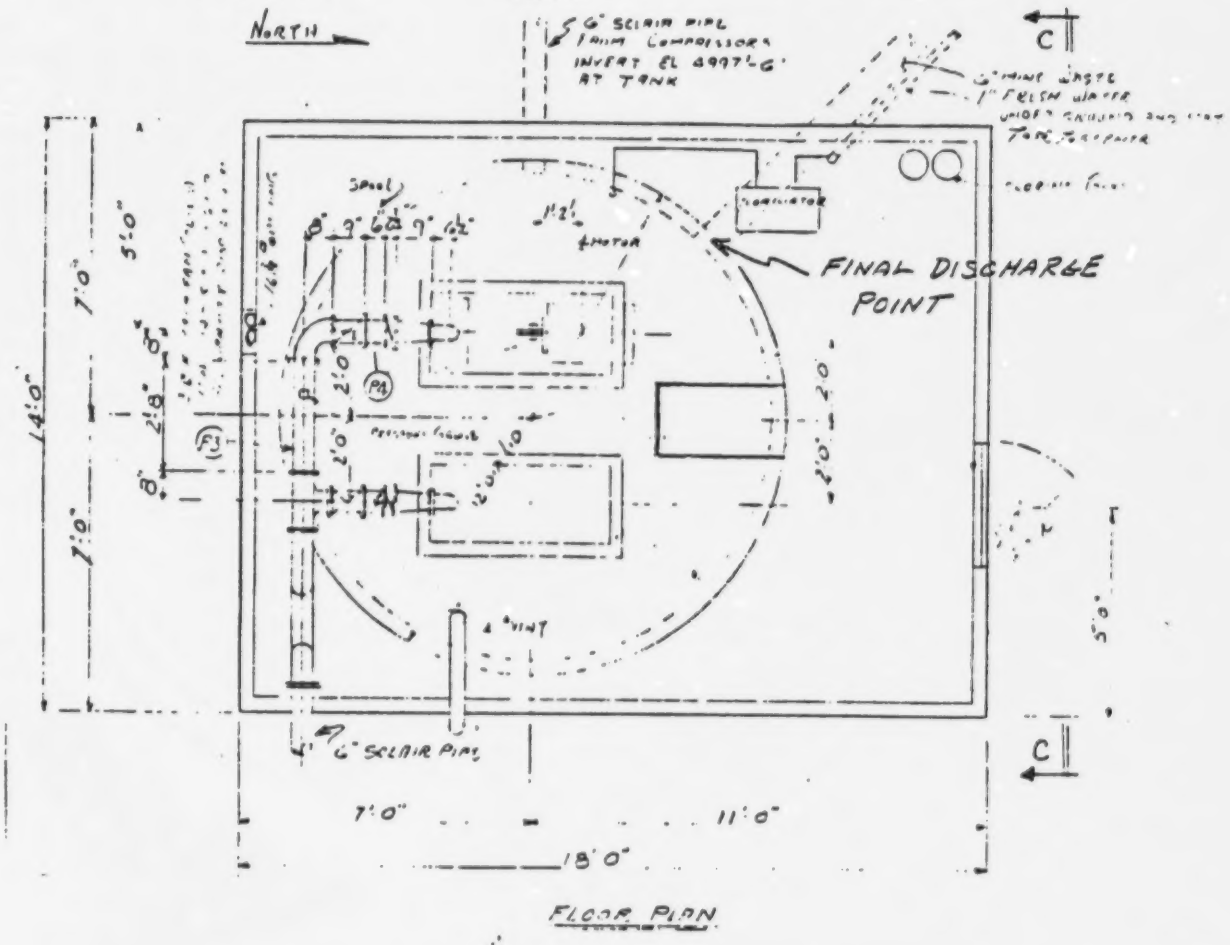
this 23rd day of March, 1984.

Chairman,
The Clean Environment Commission.

File: 1776.1

APPENDIX 'A'





FLOOR PLAN

HUDSON BAY MINING & SMELTING CO. LTD. FLIN FLON OFFICE	SPRUCE POINT MINE	
	PUMP OUT TANK AND BUILDING	
	GENERAL DRAWING	SP-92

STATION WQ0912, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT RANDOM LATITUDE 54:36 LONGITUDE 100:24

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
1	148.0	110.	110.	5. L	8.15	72.	88.	0.	0.
2	147.0	130.	130.	5. L	8.30	70.	85.	0.	0.
3	147.0	120.	120.	5. L	8.10	72.	88.	0.	0.
4	147.0	120.	120.	5. L	8.20	72.	88.	0.	0.
5	147.0	120.	120.	5. L	8.30	72.	88.	0.	0.
6	148.0	120.	120.	5. L	8.10	70.	85.	0.	0.
7	148.0	110.	110.	5. L	8.20	72.	88.	0.	0.
8	148.0	120.	120.	5. L	8.20	72.	88.	0.	0.
9	148.0	130.	130.	5. L	8.30	72.	88.	0.	0.
10	148.0	130.	130.	5. L	8.20	72.	88.	0.	0.
11	148.0	130.	130.	5. L	8.20	72.	88.	0.	0.
12	148.0	120.	120.	5. L	8.05	72.	88.	0.	0.
13	148.0	110.	110.	5. L	8.25	72.	88.	0.	0.
14	148.0	130.	130.	5. L	8.10	74.	90.	0.	0.
15	148.0	120.	120.	5. L	8.20	74.	90.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
4	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
6	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
7	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
8	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
9	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
10	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
11	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010	0.02 L	16.	9.
12	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	8.
13	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
14	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
15	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.

STATION WQ0912, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT RANDOM LATITUDE 54:36 LONGITUDE 100:24

DATE - 830810

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
1	78.	0.02 L	0.03	5. L	2.	9.2	17.5	15.0	5.
2	78.	0.02	0.04	5. L	2.	9.6	18.0	14.5	10.
3	78.	0.02	0.03	5. L	2.	9.[illegible]	11.0	15.0	10.
4	78.	0.02	0.04	5. L	2.	9.[illegible]	15.5	15.0	10.
5	79.	0.02	0.03	5. L	2.	9.4	15.0	14.5	10.
6	79.	0.02	0.03	5. L	2.	8.9	15.5	14.5	5.
7	79.	0.02 L	0.03	5. L	2.	9.6	14.5	14.5	10.
8	79.	0.02	0.04	5. L	2.	9.8	14.5	14.0	5.
9	80.	0.02	0.04	5. L	2.	9.6	12.0	15.0	5.
10	79.	0.02	0.04	5. L	2.	9.6	14.0	15.0	10.
11	76.	0.02 L	0.04	5. L	3.	9.7	18.5	14.5	10.
12	74.	0.02 L	0.03	5. L	2.	9.5	19.5	14.5	5.
13	75.	0.02	0.05	5. L	2.	9.5	19.5	15.0	10.
14	77.	0.02	0.06	5. L	2.	9.8	18.5	15.0	10.
15	76.	0.02	0.04	5. L	2.	9.5	19.5	14.5	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
1	0.95	0.40	0.02 L	0.01 L	0.020	2. L	3.	6.50	0.32
2	1.00	0.45	0.02	0.01 L	0.020	2. L	4.	4.20	4.00
3	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	5.50	5.20
4	0.90	0.45	0.02 L	0.01 L	0.015	2. L	4.	4.20	3.60
5	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	1.80	0.20
6	0.95	0.35	0.02 L	0.01 L	0.015	2. L	4.	1.40	0.20
7	1.00	0.35	0.02 L	0.01 L	0.015	2. L	4.	4.20	1.00
8	1.00	0.35	0.02 L	0.01 L	0.020	2. L	4.	7.20	3.00
9	1.00	0.35	0.02 L	0.01 L	0.015	2. L	4.	3.00	0.48
10	2.00	0.35	0.02 L	0.01 L	0.015	2. L	4.	5.20	1.40
11	1.50	0.35	0.02 L	0.01 L	0.015	2. L	4.	3.20	1.60
12	1.00	0.40	0.02 L	0.01 L	0.020	2. L	4.	2.20	2.00
13	1.00	0.35	0.02 L	0.01 L	0.015	2. L	4.	0.80	0.40
14	1.00	0.40	0.02 L	0.01 L	0.020	2. L	3.	2.00	1.50
15	1.00	0.40	0.02 L	0.01 L	0.020	2. L	4.	3.00	1.30

STATION WQ0913, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT A-1 LATITUDE 54:35 LONGITUDE 100:25

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
A-1-1	148.0	100.	100.	5. L	8.30	72.	88.	0.	0.
A-1-2	148.0	96.	96.	5. L	8.25	72.	88.	0.	0.
A-1-3	148.0	100.	100.	5. L	8.25	72.	88.	0.	0.
A-1-4	148.0	96.	96.	5. L	8.30	72.	88.	0.	0.
A-1-5	148.0	100.	100.	5. L	8.10	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
A-1-1	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.03	17.	9.
A-1-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.06	17.	9.
A-1-3	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-1-4	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-1-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
A-1-1	78.	0.02	0.05	5. L	3.	9.9	14.5	14.5	5.
A-1-2	77.	0.02	0.08	5. L	2.	9.2	13.0	14.0	5.
A-1-3	78.	0.02	0.05	5. L	2.	8.9	12.5	15.0	5.
A-1-4	78.	0.02	0.04	5. L	2.	9.2	16.5	14.5	10.
A-1-5	77.	0.02	0.04	5. L	2.	9.3	16.5	15.0	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
A-1-1	1.50	0.40	0.02 L	0.01 L	0.020	2. L	4.	1.40	0.70
A-1-2	0.95	0.40	0.02 L	0.01 L	0.020	2. L	4.	1.40	0.70
A-1-3	0.95	0.35	0.02 L	0.01 L	0.015	2. L	3.	1.20	0.06
A-1-4	1.00	0.40	0.02 L	0.01 L	0.020	2. L	3.	1.20	0.02
A-1-5	0.95	0.40	0.02 L	0.01 L	0.020	2. L	3.	1.00	0.90

STATION WQ0914, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT A-2 LATITUDE 54:35 LONGITUDE 100:24

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
A-2-1	148.0	100.	100.	5. L	8.30	72.	88.	0.	0.
A-2-2	148.0	98.	98.	5. L	8.30	72.	88.	0.	0.
A-2-3	148.0	100.	100.	5. L	8.25	72.	88.	0.	0.
A-2-4	148.0	100.	100.	5. L	8.30	72.	88.	0.	0.
A-2-5	147.0	98.	98.	5. L	8.25	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
A-2-1	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.03	17.	9.
A-2-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-2-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-2-4	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-2-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
A-2-1	78.	0.02	0.05	5. L	2.	8.7	12.0	14.5	5.
A-2-2	78.	0.02	0.04	5. L	2.	8.9	13.5	14.5	10.
A-2-3	81.	0.02	0.04	5. L	2.	8.7	16.0	14.5	5.
A-2-4	80.	0.02	0.04	5. L	2.	8.2	17.0	15.0	10.
A-2-5	80.	0.02	0.04	5. L	2.	8.4	17.5	15.0	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
A-2-1	1.00	0.40	0.02 L	0.01 L	0.015	2. L	3.	1.40	0.60
A-2-2	1.00	0.35	0.02 L	0.01 L	0.020	2. L	3.	1.50	0.50
A-2-3	1.00	0.40	0.02 L	0.01 L	0.015	2. L	3.	3.60	1.70
A-2-4	1.50	0.35	0.02 L	0.01 L	0.015	2. L	4.	2.10	1.30
A-2-5	1.00	0.40	0.02 L	0.01 L	0.020	2. L	4.	3.00	0.80

STATION WQ0915, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT A-3 LATITUDE 54:35 LONGITUDE 100:23

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
A-3-1	147.0	100.	100.	5. L	8.25	74.	90.	0.	0.
A-3-2	147.0	92.	92.	5. L	8.20	68.	83.	0.	0.
A-3-3	147.0	96.	96.	5. L	8.25	70.	85.	0.	0.
A-3-4	147.0	100.	100.	5. L	8.20	72.	88.	0.	0.
A-3-5	147.0	96.	96.	5. L	8.25	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
A-3-1	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-3-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-3-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-3-4	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-3-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
A-3-1	80.	0.02 L	0.03	5. L	2.	8.3	11.5	15.0	10.
A-3-2	80.	0.02 L	0.04	5. L	2.	8.7	15.5	15.0	10.
A-3-3	80.	0.02	0.04	5. L	3.	9.7	11.5	14.5	10.
A-3-4	80.	0.02 L	0.03	5. L	2.	9.6	19.0	14.5	10.
A-3-5	80.	0.02 L	0.03	5. L	2.	8.6	11.5	14.0	5.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
A-3-1	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	3.20	1.60
A-3-2	0.95	0.45	0.02 L	0.01 L	0.020	2. L	4.	4.10	2.50
A-3-3	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	4.20	3.80
A-3-4	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	4.60	1.50
A-3-5	0.90	0.45	0.02 L	0.01 L	0.015	2. L	4.	5.50	1.25

STATION WQ0916, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT A-4 LATITUDE 54:35 LONGITUDE 100:22

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
A-4-1	147.0	86.	86.	5. L	8.05	72.	88.	0.	0.
A-4-2	147.0	96.	96.	5. L	8.25	74.	90.	0.	0.
A-4-3	148.0	96.	96.	5. L	8.20	72.	88.	0.	0.
A-4-4	148.0	110.	110.	5. L	8.25	70.	85.	0.	0.
A-4-5	148.0	110.	110.	5. L	8.20	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
A-4-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-4-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-4-3	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-4-4	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
A-4-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
A-4-1	80.	0.02	0.04	5. L	2.	8.9	15.5	14.5	10.
A-4-2	80.	0.02	0.04	5. L	2.	8.6	15.5	14.0	10.
A-4-3	78.	0.02	0.04	5. L	2.	8.7	12.5	14.0	10.
A-4-4	78.	0.04	0.04	5. L	2.	8.8	17.5	14.0	10.
A-4-5	79.	0.02	0.07	5. L	2.	9.0	13.0	14.5	5.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
A-4-1	0.65	0.45	0.02 L	0.01 L	0.020	2. L	4.	3.60	0.70
A-4-2	1.00	0.45	0.02 L	0.01 L	0.020	2. L	4.	4.20	2.50
A-4-3	1.50	0.45	0.02 L	0.01 L	0.015	2. L	4.	4.40	2.10
A-4-4	1.00	0.45	0.02 L	0.01 L	0.015	2. L	4.	3.30	1.20
A-4-5	1.00	0.40	0.02 L	0.01 L	0.020	2. L	4.	2.90	2.80

STATION WQ0917, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT B-1 LATITUDE 54:35 LONGITUDE 100:21

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
B-1	170.0	140.	140.	8.	7.95	84.	103.	0.	0.
B-1-1	162.0	140.	130.	8.	8.10	80.	98.	0.	0.
B-1-2	165.0	120.	120.	5.	8.10	82.	100.	0.	0.
B-1-3	159.0	120.	110.	6.	8.20	78.	95.	0.	0.
B-1-4	150.0	130.	130.	5. L	8.30	74.	90.	0.	0.
B-1-5	152.0	110.	110.	5. L	8.30	74.	90.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
B-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	24.	13.
B-1-1	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.04	18.	10.
B-1-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.06	18.	9.
B-1-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	18.	3.
B-1-4	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.08	17.	9.
B-1-5	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.060	0.03	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
B-1	111.	0.03	0.29	5. L	3.	8.5	12.0	20.5	10.
B-1-1	86.	0.02 L	0.10	5. L	2.	8.5	13.5	18.5	15.
B-1-2	84.	0.02 L	0.09	5. L	3.	8.5	15.0	18.0	15.
B-1-3	84.	0.02 L	0.08	5. L	2.	8.6	11.0	19.5	10.
B-1-4	79.	0.02 L	0.06	5. L	2.	8.9	12.5	17.0	10.
B-1-5	78.	0.02	0.06	5. L	2.	8.8	11.5	15.5	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
B-1	1.00	0.70	0.02 L	0.01 L	0.020	2. L	5.	0.80	0.20
B-1-1	1.50	0.60	0.02 L	0.01 L	0.020	2. L	4.	1.10	0.60
B-1-2	1.50	0.60	0.02 L	0.01 L	0.020	2. L	4.	1.30	1.00
B-1-3	1.00	0.60	0.02 L	0.01 L	0.020	2. L	4.	2.00	1.50
B-1-4	1.50	0.60	0.02 L	0.01 L	0.020	2. L	3.	2.50	2.20
B-1-5	1.00	0.60	0.02 L	0.01 L	0.020	2. L	3.	3.00	1.50

STATION WQ0918, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT B-2 LATITUDE 54:35 LONGITUDE 100:20

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
B-2	170.0	140.	140.	8.	7.95	84.	103.	0.	0.
B-2-1	154.0	130.	120.	8.	8.20	76.	93.	0.	0.
B-2-2	152.0	120.	110.	6.	8.30	74.	90.	0.	0.
B-2-3	151.0	120.	120.	6.	8.39	74.	90.	0.	0.
B-2-4	151.0	110.	110.	5.	8.33	72.	88.	0.	0.
B-2-5	149.0	120.	120.	5. L	8.30	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
B-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	24.	13.
B-2-1	0.002	0.001	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
B-2-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
B-2-3	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
B-2-4	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
B-2-5	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.03	16.	9.

SITE	HARDNESS G(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
B-2	111.	0.03	0.29	5. L	3.	8.5	12.0	20.5	10.
B-2-1	81.	0.02	0.24	5. L	3.	9.0	11.5	16.5	5.
B-2-2	78.	0.02 L	0.06	5. L	2.	9.0	11.0	16.5	10.
B-2-3	78.	0.02 L	0.05	5. L	2.	10.0	14.0	16.5	10.
B-2-4	76.	0.02 L	0.05	5. L	2.	9.5	15.0	15.5	10.
B-2-5	76.	0.02 L	0.05	5. L	2.	11.2	15.0	15.5	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
B-2	1.00	0.70	0.02 L	0.01 L	0.020	2. L	5.	0.60	0.20
B-2-1	1.00	0.60	0.02 L	0.01 L	0.020	2. L	3.	1.40	0.05
B-2-2	1.50	0.60	0.02 L	0.01 L	0.020	2. L	3.	3.00	2.40
B-2-3	1.50	0.60	0.02 L	0.01 L	0.020	2. L	4.	3.30	1.90
B-2-4	1.50	0.60	0.02 L	0.01 L	0.020	2. L	4.	4.00	3.00
B-2-5	0.95	0.60	0.02 L	0.01 L	0.020	2. L	4.	3.50	3.10

STATION WQ0919, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT B-3 LATITUDE 54:35 LONGITUDE 100:19

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
B-3	170.0	140.	140.	8.	7.95	34.	103.	0.	0.
B-3-1	163.0	110.	110.	5. L	8.10	80.	98.	0.	0.
B-3-2	153.0	130.	120.	8.	8.30	74.	90.	0.	0.
B-3-3	152.0	130.	130.	5. L	8.30	72.	88.	0.	0.
B-3-4	152.0	120.	120.	5.	8.20	74.	90.	0.	0.
B-3-5	151.0	120.	120.	5. L	8.30	74.	90.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
B-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	24.	13.
B-3-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.03	18.	9.
B-3-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
B-3-3	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
B-3-4	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
B-3-5	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
B-3	111.	0.03	0.29	5. L	3.	8.5	12.0	20.5	10.
B-3-1	83.	0.02	0.10	5. L	3.	8.5	11.5	17.5	10.
B-3-2	77.	0.02 L	0.07	5. L	2.	8.9	13.0	15.5	10.
B-3-3	77.	0.02 L	0.06	5. L	2.	8.8	17.0	17.5	10.
B-3-4	77.	0.02 L	0.07	5. L	2.	9.1	13.0	16.5	10.
B-3-5	78.	0.02 L	0.06	5. L	2.	8.9	12.5	16.0	5.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
B-3	1.00	0.70	0.02 L	0.01 L	0.020	2. L	5.	0.80	0.20
B-3-1	1.50	0.70	0.02 L	0.01 L	0.020	2. L	4.	1.20	0.70
B-3-2	1.50	0.70	0.02 L	0.01 L	0.020	2. L	3.	3.00	1.00
B-3-3	1.50	0.60	0.02 L	0.01 L	0.015	2. L	3.	3.50	0.20
B-3-4	1.50	0.70	0.02 L	0.01 L	0.020	2. L	3.	3.20	2.50
B-3-5	1.50	0.60	0.02 L	0.01 L	0.015	2. L	3.	1.50	0.40

STATION WQ0920, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT C-1 LATITUDE 54:35 LONGITUDE 100:18

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
C-1	371.0	270.	270.	5.	7.45	200.	244.	0.	0.
C-1-1	169.0	140.	130.	8.	8.10	84.	103.	0.	0.
C-1-2	147.0	120.	120.	5. L	8.30	72.	88.	0.	0.
C-1-3	147.0	120.	120.	5. L	8.30	76.	93.	0.	0.
C-1-4	149.0	130.	120.	8.	8.20	72.	88.	0.	0.
C-1-5	149.0	100.	100.	5. L	8.10	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
C-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	44.	25.
C-1-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	18.	10.
C-1-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
C-1-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	8.
C-1-4	0.001 L	0.001 L	0.010 L	0.005 L	0 005 L	0.010 L	0.02 L	16.	9.
C-1-5	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
C-1	211.	0.03	0.60	5. L	4.	3.1	21.5	50.0	50.
C-1-1	87.	0.02 L	0.07	5. L	2.	10.0	12.0	18.5	15.
C-1-2	75.	0.02 L	0.03	5. L	2.	8.9	14.0	21.0	10.
C-1-3	75.	0.02 L	0.03	5. L	2.	9.0	18.0	16.5	5.
C-1-4	76.	0.02 L	0.04	5. L	2.	8.9	11.0	16.0	10.
C-1-5	75.	0.02 L	0.04	5. L	2.	9.2	11.5	16.0	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
C-1	1.00	0.80	0.02 L	0.01 L	0.020	2. L	3.	0.80	0.20
C-1-1	1.50	0.60	0.02 L	0.01 L	0.020	2. L	3.	1.10	0.90
C-1-2	1.00	0.60	0.02 L	0.01 L	0.015	2. L	4.	1.20	0.30
C-1-3	1.10	0.60	0.02 L	0.03	0.015	2. L	4.	1.30	0.60
C-1-4	1.00	0.60	0.02 L	0.01 L	0.015	2 L	3.	1.50	0.40
C-1-5	1.00	0.70	0.02 L	0.01 L	0.015	2. L	3.	2.20	0.70

STATION WQ0921, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT C-2 LATITUDE 54:35 LONGITUDE 100:17

DATE - 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
C-2	371.0	270.	270.	5.	7.43	200.	244.	0.	0.
C-2-1	162.0	110.	110.	5. L	8.00	78.	95.	0.	0.
C-2-2	147.0	94.	94.	5. L	8.30	72.	88.	0.	0.
C-2-3	148.0	98.	98.	5. L	8.30	72.	88.	0.	0.
C-2-4	148.0	100.	100.	5. L	8.30	70.	85.	0.	0.
C-2-5	147.0	100.	100.	5. L	8.30	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
C-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	44.	25.
C-2-1	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.
C-2-2	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	8.
C-2-3	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	8.
C-2-4	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
C-2-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
C-2	211.	0.03	0.60	5. L	4.	8.1	21.5	50.0	50.
C-2-1	79.	0.02 L	0.04	5. L	3.	9.1	12.5	18.0	10.
C-2-2	75.	0.02 L	0.03	5. L	2.	9.1	11.0	15.5	5.
C-2-3	75.	0.02 L	0.04	5. L	2.	9.0	10.5	15.5	10.
C-2-4	76.	0.02 L	0.03	5. L	2.	9.1	11.0	14.0	10.
C-2-5	76.	0.02 L	0.03	5. L	2.	9.0	12.0	15.5	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
C-2	1.00	0.80	0.02 L	0.01 L	0.020	2. L	3.	0.80	0.20
C-2-1	0.95	0.70	0.02 L	0.01 L	0.020	2. L	3.	1.10	0.80
C-2-2	1.00	0.70	0.02 L	0.01 L	0.020	2. L	3.	1.40	0.20
C-2-3	1.50	0.70	0.02 L	0.01 L	0.020	2. L	3.	1.90	0.80
C-2-4	1.00	0.70	0.02 L	0.01 L	0.015	2. L	3.	3.20	0.60
C-2-5	1.50	0.70	0.02 L	0.01 L	0.020	2. L	3.	2.20	0.70

STATION WQ0922, SOURCE - REED LAKE
SAMPLING LOCATION - SPRUCE POINT C-3 LATITUDE 54:35 LONGITUDE 100:16

DATE 830810

SITE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
C-3	371.0	270.	270.	5.	7.45	200.	244.	0.	0.
C-3-1	181.0	120.	120.	5. L	8.00	88.	107.	0.	0.
C-3-2	148.0	100.	100.	5. L	8.30	72.	88.	0.	0.
C-3-3	148.0	100.	100.	5. L	8.20	72.	88.	0.	0.
C-3-4	148.0	96.	96.	5. L	8.20	72.	88.	0.	0.
C-3-5	149.0	96.	96.	5. L	8.00	72.	88.	0.	0.

SITE	ARSENIC MG(AS)/L	CADMIUM MG(CD)/L	COPPER MG(CU)/L	LEAD MG(PB)/L	NICKEL MG(NI)/L	ZINC MG(ZN)/L	MERCURY UG(HG)/L	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L
C-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	44.	25.
C-3-1	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.03	20.	11.
C-3-2	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
C-3-3	0.001	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
C-3-4	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	16.	9.
C-3-5	0.001 L	0.001 L	0.010 L	0.005 L	0.005 L	0.010 L	0.02 L	17.	9.

SITE	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	T.O.C. MG(C)/L	T.I.C. MG(C)/L	TRUE COLOUR COLOUR UNITS
C-3	211.	0.03	0.60	5. L	4.	3.1	21.5	50.0	50.
C-3-1	94.	0.02 L	0.10	5. L	3.	8.5	14.0	20.0	15.
C-3-2	77.	0.02 L	0.03	5. L	2.	9.6	11.0	15.5	10.
C-3-3	77.	0.02 L	0.03	5. L	2.	9.1	12.0	16.5	5.
C-3-4	76.	0.02 L	0.04	5. L	2.	9.3	11.5	15.5	5.
C-3-5	77.	0.02 L	0.04	5. L	2.	9.?	11.5	15.5	10.

SITE	TURBIDITY NTU	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	TOTAL DEPTH METRES	SAMPLE DEPTH METRES
C-3	1.00	0.80	0.02 L	0.01 L	0.020	2. L	3.	0.80	0.20
C-3-1	1.00	0.75	0.02 L	0.01 L	0 020	2. L	3.	1.10	0.60
C-3-2	1.00	0.70	0.02 L	0.01 L	0.015	2. L	4.	1.40	0.80
C-3-3	1.00	0.70	0.02 L	0.01 L	0.020	2. L	4.	4.40	4.00
C-3-4	1.00	0.70	0.02 L	0.01 L	0.020	2. L	4.	5.30	2.60
C-3-5	1.00	0.70	0.02 L	0.01 L	0.020	2. L	4.	5.40	4.10

APPENDIX III: REED LAKE SEDIMENT DATA

III (a): Data from the random block

		METAL CONCENTRATIONS (µg/g DRY WEIGHT)									
SITE*	SEDIMENT**	Hg(Wet)***	Hg	As	Cd	Cu	Pb	Ni	Zn	Fe	Mn
1	SS	<0.02	<0.03	2.42	<1	19	10	14	48	15930	354
2	S	<0.02	<0.03	1.65	<1	12	<5	11	36	11590	233
3	S	<0.02	<0.03	2.02	<1	11	5	11	36	12310	207
4	S&G	<0.02	<0.03	2.20	<1	13	<5	11	34	13760	220
5	S	<0.02	<0.03	4.83	<1	17	5	21	33	30420	534
6	S	<0.02	<0.03	0.61	<1	<1.0	<5	<5	6	1450	30
7	S&G	<0.02	<0.03	1.96	<1	17	<5	18	47	12310	147
8	SS	<0.02	<0.03	1.14	<1	5	<5	<5	16	6520	160
9	S	<0.02	<0.03	0.92	<1	7	<5	<5	22	5790	83
10	S	<0.02	<0.04	15.5	<1	41	28	64	120	54310	5003
11	S&G	<0.02	<0.03	2.25	<1	17	<5	14	26	15930	220
12	S	<0.02	<0.03	1.41	<1	17	10	7	23	12310	133
13	SS	<0.02	<0.03	1.69	<1	18	5	7	31	12310	173
14	SS	<0.02	<0.04	2.53	<1	12	5	14	34	13040	247
15	S	<0.02	<0.03	1.13	<1	7	<5	<5	22	6520	93

* Sites per Figure 2
** Where S = sand; SS = silty sand; S&G = sand & gravel
*** Due to potential volatilization loss, mercury is also reported as Wet Weight

III (b): Data from the "A" Series of Radii

		METAL CONCENTRATIONS (µg/g DRY WEIGHT)									
SITE*	SEDIMENT**	Hg(Wet)***	Hg	As	Cd	Cu	Pb	Ni	Zn	Fe	Mn
A-1-1	S	<0.02	<0.03	1.02	<1	5	5	<5	5	1450	30
A-1-2	S	<0.02	<0.03	0.82	<1	2	<5	<5	5	1450	33
A-1-3	S	<0.02	<0.03	0.81	<1	<2	<5	<5	6	1450	53
A-1-4	S	<0.02	<0.03	0.63	<1	<2	<5	<5	4	1090	17
A-1-5	S	<0.02	<0.03	0.96	<1	5	5	<5	7	1810	17
A-2-1	S	<0.02	<0.03	0.73	<1	2	<5	<5	6	1450	27
A-2-2	S	<0.02	<0.03	0.68	<1	4	<5	<5	6	1450	23
A-2-3	S	<0.02	<0.03	1.40	<1	5	<5	7	14	3980	43
A-2-4	S	<0.02	<0.03	1.00	<1	4	<5	7	16	4710	60
A-2-5	S	<0.02	<0.03	1.26	<1	8	5	7	17	6520	73
A-3-1	S	<0.02	<0.03	1.06	<1	7	5	7	21	4710	67
A-3-2	S	<0.02	<0.03	1.25	<1	7	<5	7	21	6520	100
A-3-3	S	<0.02	<0.03	1.84	<1	7	5	7	17	9410	260
A-3-4	S	<0.02	<0.03	1.02	<1	5	<5	7	15	5430	127
A-3-5	SS	<0.02	<0.03	1.38	<1	10	5	14	32	11590	27
A-4-1	SS	<0.02	<0.03	1.42	<1	7	<5	7	23	7970	147
A-4-2	SS	<0.02	<0.03	1.18	<1	6	<5	7	21	6880	113
A-4-3	S	<0.02	<0.03	1.02	<1	5	<5	7	11	5790	67
A-4-4	S	<0.02	<0.03	2.90	<1	21	<5	21	37	21730	280
A-4-5	S	<0.02	<0.03	1.31	<1	10	<5	11	21	7970	87

* Sites per Figure 3, Table 1
** Where: S = sand; SS = silty sand; S&G = sand & gravel
*** Due to potential volatilization loss, mercury is also reported as Wet Weight

III (c): Data from the "B" Series of Radii

		METAL CONCENTRATIONS (µg/g DRY WEIGHT)									
SITE*	SEDIMENT**	Hg(Wet)***	Hg	As	Cd	Cu	Pb	Ni	Zn	Fe	Mn
B	S	<0.02	<0.03	0.45	<1	<1	<5	<5	6	1810	17
B-1-1	S	<0.02	<0.03	0.45	<1	4	<5	7	6	1450	13
B-1-2	S	<0.02	<0.03	0.39	<1	<1	<5	<5	5	1090	13
B-1-3	S	<0.02	<0.03	0.35	<1	<1	<5	<5	4	1090	13
B-1-4	SS-H	<0.02	<0.03	2.90	<1	21	18	<5	49	21000	1001
B-1-5	SS-H	<0.02	<0.04	1.74	<1	16	<5	25	31	11590	467
B-2-1	S	0.02	0.03	0.48	<1	5	<5	14	6	1450	27
B-2-2	S	0.02	0.03	1.63	<1	8	<5	<5	23	9780	140
B-2-3	SS	0.02	0.03	1.50	<1	10	10	<5	28	10500	160
B-2-4	SS	0.03	0.04	1.35	<1	10	5	<5	35	10140	150
B-2-5	SS	0.02	0.03	1.19	<1	6	5	<5	18	6520	110
B-3-1	S	<0.02	<0.03	0.47	<1	2	<5	<5	5	1450	19
B-3-2	SS-H	0.02	0.03	3.20	<1	36	18	36	82	35480	490
B-3-3	SS-H	0.03	0.04	2.75	<1	23	10	21	70	27520	380
B-3-4	S	<0.02	<0.03	2.20	<1	24	10	21	47	19550	227
B-3-5	SS	<0.02	<0.03	1.21	<1	7	5	7	21	7240	140

* Sites per Figure 3, Table 1

** Where: S = sand; SS = silty sand; H = hardpan

*** Due to potential volatilization loss, mercury is also reported as Wet Weight

III (d): Data from the "C" Series of Radii

		METAL CONCENTRATIONS (µg/g DRY WEIGHT)									
SITE*	SEDIMENT**	Hg(Wet)***	Hg	As	Cd	Cu	Pb	Ni	Zn	Fe	Mn
C	S	<0.02	<0.03	0.76	<1	<1	<5	<5	6	1810	17
C-1-1	S	<0.02	<0.03	0.51	<1	<1	<5	<5	5	1450	17
C-1-2	S	<0.02	<0.03	0.59	<1	<1	<5	<5	4	720	7
C-1-3	S	<0.02	<0.03	0.61	<1	2	<5	<5	4	720	20
C-1-4	S	<0.02	<0.03	0.60	<1	5	<5	<5	4	1450	20
C-1-5	SS	<0.02	<0.03	1.09	<1	5	<5	<5	14	5070	87
C-2-1	S	<0.02	<0.03	0.63	<1	1	<5	<5	4	720	10
C-2-2	S	<0.02	<0.03	0.63	<1	<1	<5	<5	4	720	17
C-2-3	S&H	<0.02	<0.03	2.14	<1	14	<5	14	37	14480	387
C-2-4	SS	<0.02	<0.03	1.58	<1	14	5	14	33	10860	233
C-2-5	SS	<0.02	<0.03	1.02	<1	5	5	<5	16	4710	113
C-3-1	S	<0.02	<0.03	0.67	<1	4	<5	<5	6	1090	10
C-3-2	S	<0.02	<0.03	0.49	<1	<1	<5	<5	4	720	10
C-3-3	H	<0.02	<0.03	1.76	<1	10	5	7	28	9780	187
C-3-4	H	<0.02	<0.03	1.39	<1	6	<5	<5	16	5790	173
C-3-5	SS-H	<0.02	<0.04	3.45	<1	18	5	21	50	19550	600

* Sites per Figure 3, Table 1
** Where: S = sand; SS = silty sand; H = hardpan
*** Due to potential volatilization loss, mercury is also reported as Wet Weight

APPENDIX IV (a): Reed Lake Fish Data: Common Sucker

YEAR=1983 SITE=REED LAKE SPECIES=COMMON SUCKER

YEAR=83 SITE=BM036 SPECIES=21

OBS	LENGTH	WEIGHT	AGE	SEX	AS(M)	CD(M)	CR(M)	CU(M)	PB(M)	HG(M)	NI(M)	ZN(M)
1	37.1	840	8	3	0.05	L0.1	.	0.1	L0.5	0.06	L0.5	3.8
2	36.7	800	6	3	0.04	L0.1	.	0.2	L0.5	0.02	L0.5	3.7
3	39.3	850	9	3	0.03	L0.1	.	0.1	L0.5	0.07	L0.5	3.3
4	38.4	870	9	2	0.04	L0.1	.	0.1	L0.5	0.06	L0.5	3.7
5	40.5	1000	11	2	0.03	L0.1	.	0.1	L0.5	0.07	L0.5	3.1
6	41.9	1180	10	3	0.02	L0.1	.	0.5	L0.5	0.09	L0.5	3.1
7	40.2	900	6	3	0.04	L0.1	.	0.2	0.5	0.04	L0.5	2.4
8	38.1	820	6	3	0.03	L0.1	.	0.4	L0.5	0.04	L0.5	3.1
9	39.8	970	9	3	0.04	L0.1	.	0.6	L0.5	0.06	L0.5	3.7
10	36.9	670	6	3	0.03	L0.1	.	0.2	1.5	0.07	L0.5	4.5
11	38.2	790	7	3	0.03	L0.1	.	0.2	1.5	0.03	L0.5	3.1
12	36.8	820	6	3	0.05	L0.1	.	0.2	L0.5	0.03	L0.5	2.9
13	43.6	1260	11	3	0.04	L0.1	.	0.2	1.0	0.07	L0.5	2.2
14	37.3	820	6	3	0.04	L0.1	.	0.4	1.3	0.03	L0.5	3.9
15	41.0	960	10	2	0.05	L0.1	.	0.2	L0.5	0.06	L0.5	2.2
16	38.3	920	9	3	0.02	L0.1	.	0.2	L0.5	0.04	L0.5	3.1
17	43.8	1360	13	3	0.03	L0.1	.	0.2	L0.5	0.08	L0.5	3.7
18	41.0	1050	6	3	0.06	L0.1	.	0.1	L0.5	0.03	L0.5	2.7
19	40.9	1100	9	3	0.01	L0.1	.	0.4	L0.5	0.04	L0.5	4.0
20	41.7	1000	9	2	0.03	L0.1	.	0.1	L0.5	0.03	L0.5	3.6

APPENDIX IV (b): Reed Lake Fish Data: Walleye

YEAR=1983 SITE=REED LAKE SPECIES=WALLEYE

YEAR=83 SITE=BM036 SPECIES=17

OBS	LENGTH	WEIGHT	AGE	SEX	AS(M)	CD(M)	CR(M)	CU(M)	PB(M)	HG(M)	NI(M)	ZN(M)
1	33.6	470	8	3	0.07	L 0.1	.	0.2	L 0.5	0.05	L 0.5	4.6
2	43.8	990	7	3	0.05	L 0.1	.	0.2	L 0.5	0.11	L 0.5	4.1
3	44.0	1040	7	3	0.03	L 0.1	.	0.2	L 0.5	0.10	L 0.5	3.5
4	42.5	1000	8	3	0.06	L 0.1	.	0.7	L 0.5	0.16	L 0.5	5.6
5	49.5	1340	.	3	0.06	L 0.1	.	0.2	L 0.5	0.19	L 0.5	4.4
6	46.7	1320	.	3	0.03	L 0.1	.	0.2	0.5	0.24	L 0.5	4.3
7	43.2	980	7	3	0.02	L 0.1	.	0.1	1.0	0.16	L 0.5	4.2
8	48.9	1420	.	3	0.05	L 0.1	.	0.2	L 0.5	0.17	L 0.5	4.3
9	41.9	850	7	2	0.04	L 0.1	.	0.1	L 0.5	0.15	L 0.5	3.2
10	47.0	1240	11	2	0.04	L 0.1	.	0.2	L 0.5	0.20	L 0.5	4.1
11	41.8	920	7	2	0.04	L 0.1	.	0.2	L 0.5	0.14	L 0.5	4.0
12	43.1	1010	8	2	0.03	L 0.1	.	0.2	L 0.5	0.17	L 0.5	4.0
13	44.5	1160	11	2	0.04	L 0.1	.	0.1	L 0.5	0.19	L 0.5	4.3
14	44.0	980	8	3	0.04	L 0.1	.	0.2	L 0.5	0.16	L 0.5	4.4
15	49.2	1360	6	3	0.04	L 0.1	.	0.6	L 0.5	0.15	L 0.5	8.1
16	48.0	1440	13	3	0.04	L 0.1	.	0.2	L 0.5	0.28	L 0.5	3.4
17	55.3	1900	10	3	0.07	L 0.1	.	0.1	L 0.5	0.29	L 0.5	3.2
18	58.6	2220	12	3	0.06	L 0.1	.	0.2	0.5	0.43	L 0.5	4.5

APPENDIX IV (c): Reed Lake Fish Data: Northern Pike

YEAR=1983 SITE=REED LAKE SPECIES=NORTHERN PIKE

YEAR=83 SITE=BM036 SPECIES=25

OBS	LENGTH	WEIGHT	AGE	SEX	AS(M)	CD(M)	CR(M)	CU(M)	PB(M)	HG(M)	NI(M)	ZN(M)
1	67.3	2280	6	3	0.04	L 0.1	.	0.2	0.5	0.15	L 0.5	4.7
2	78.0	3580	6	3	0.04	L 0.1	.	0.2	0.5	0.28	L 0.5	4.6
3	31.2	260	1	1	0.04	L 0.1	.	0.4	1.0	0.04	L 0.5	4.7
4	56.5	1440	4	2	0.04	L 0.1	.	0.2	L 0.5	0.09	L 0.5	6.1
5	71.0	2520	6	3	0.03	L 0.1	.	0.2	L 0.5	0.17	L 0.5	4.9
6	71.8	2720	6	3	0.05	L 0.1	.	0.2	L 0.5	0.20	L 0.5	5.5

APPENDIX IV (d): Reed Lake Fish Data: Cisco

YEAR=1983 SITE=REED LAKE SPECIES=CISCO

YEAR=83 SITE=BM036 SPECIES=10

OBS	LENGTH	WEIGHT	AGE	SEX	AS(M)	CD(M)	CR(M)	CU(M)	PB(M)	HG(M)	NI(M)	ZN(M)
1	38.5	780	7	3	0.05	L 0.1	.	0.4	L 0.5	0.07	L 0.5	6.3
2	29.7	440	5	2	0.04	L 0.1	.	0.4	L 0.5	0.09	L 0.5	4.2
3	40.5	800	8	3	0.03	L 0.1	.	0.4	0.5	0.08	L 0.5	3.0
4	35.9	700	8	3	0.03	L 0.1	.	0.2	L 0.5	0.07	L 0.5	4.2
5	39.0	720	11	2	0.04	L 0.1	.	0.2	L 0.5	0.06	L 0.5	4.7
6	40.4	1000	7	3	0.03	L 0.1	.	0.2	L 0.5	0.08	L 0.5	3.0